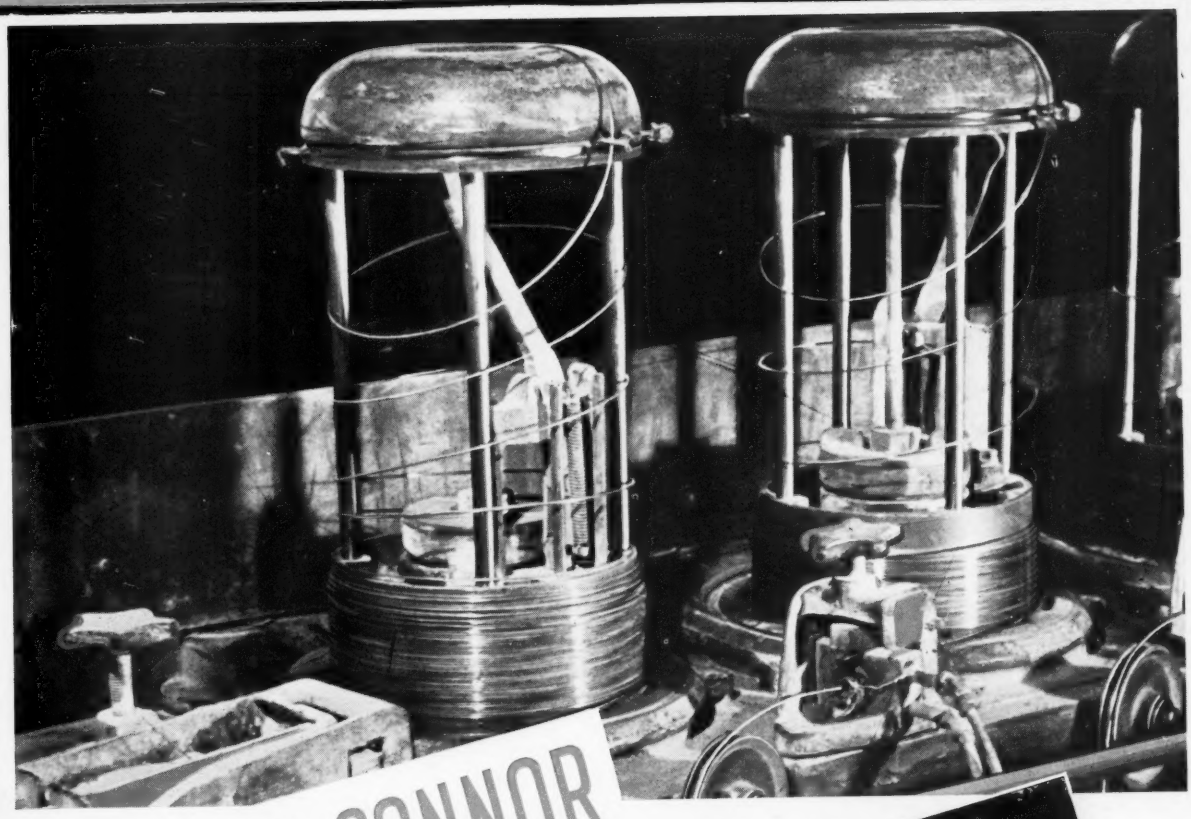
# WIRE AND WIRE PRODUCTS

OCTOBER 1937

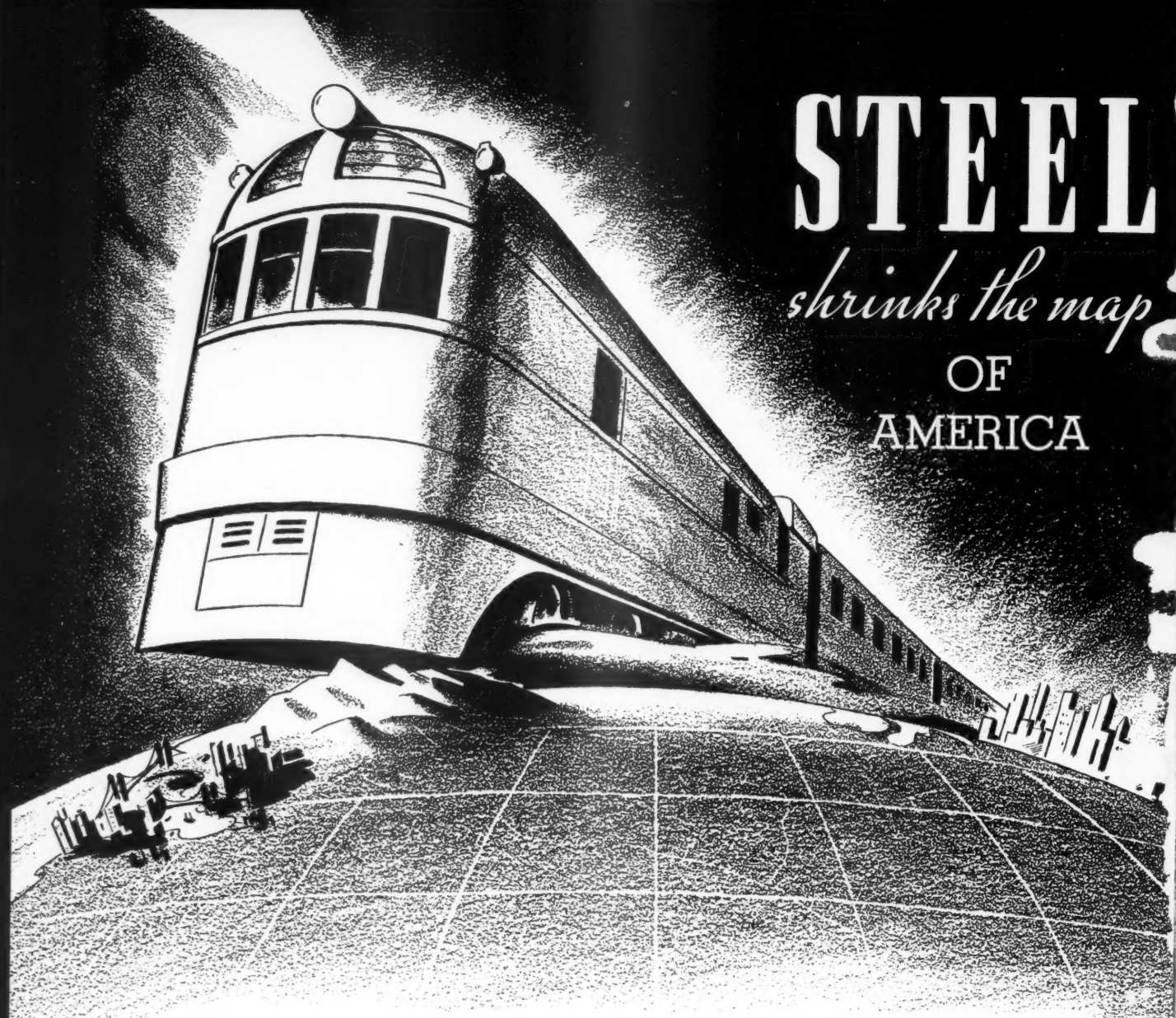


MORGAN-CONNOR

See Page 571

*Continuous Wire Drawing Machinery*

MORGAN CONSTRUCTION CO., WORCESTER, MASS.



# STEEL
## *shrinks the map* OF AMERICA

Philadelphia used to be two days from New York. Now *steel* makes it in two hours.....You can live in healthful suburbs yet work in the city, because your steel automobile makes minutes out of miles .... You can do business with the nation and the world -- instead of only a few neighbors -- because of steel machinery and transport. Because it constantly conquers distance and discomforts, *steel* makes America the most compact and progressive continent in the world.

Because steel is so definitely part of our modern life, we take it too much for granted. Do you realize that there are not scores, not hundreds but thousands of kinds of steel? Each has a certain purpose or product for which it is best suited. Here at Youngstown, when we receive an order for steel-- no matter how small nor how routine the use -- we will not begin that order until we are certain we have exactly the right steel for the purpose. This is a progressive Company, but we are old fashioned in one particular. We feel that we are working for you, the customer, more than for ourselfs. That is why you, the user of wire, can *depend on Youngstown.*

THE YOUNGSTOWN SHEET AND TUBE COMPANY

Manufacturers of Carbon and Alloy Steels

General Offices YOUNGSTOWN, OHIO

QUALITY YOUNGSTOWN SERVICE

# YOUNGSTOWN

Sheets - Plates - Pipe and Tubular Products - Conduit - Tin Plate - Bars - Rods - Wire - Nails - Unions - Tie Plates and Spikes

# An Open Letter To Carboloy Die Users . . .

**CARBOLOY COMPANY INC**

MANUFACTURERS OF
CARBOLOY CEMENTED CARBIDE TOOLS AND DIES
CARBOLOY DIAMOND IMPREGNATED DRESSERS
GENERAL OFFICES: 2985 EAST JEFFERSON AVENUE
TELEPHONE-FITZROY 4040
DETROIT
MICHIGAN

Sales Offices
CHICAGO
CLEVELAND
DETROIT

Sales Offices
NEWARK
PHILADELPHIA
PITTSBURGH

ADDRESS REPLY TO

TO ALL CARBOLOY DIE USERS

Gentlemen:

In answer to numerous inquiries received in the last few weeks regarding the present world situation affecting tungsten, it is with pleasure that we find it possible to give you the following information:

As you no doubt know, tungsten carbide is the main ingredient of Carboloy. Tungsten concentrates from China were used for the manufacture of tungsten carbide for Carboloy for several years, not only because of availability but also because of the high purity of such concentrates. In the manufacture of Carboloy, the purity of the tungsten is the same as that used in the manufacture of filament for incandescent lamps.

Because of uncertainty in connection with the continuation of an adequate supply of tungsten of the proper purity from China, the General Electric Company, during the past few years, has purchased two tungsten mines in the United States. The material from both of these mines is of the high purity demanded for Carboloy requirements.

At the moment, shipments of Chinese concentrates have been suspended and the price of tungsten has risen rapidly. However, the General Electric Company assures the Carboloy Company--its subsidiary--that an adequate supply of tungsten will be available from the operation of the domestic mines, to satisfy all Carboloy needs.

Notwithstanding the increase in the market price of tungsten, we have every reason to believe that the price of cemented carbide manufactured by the Carboloy Company will not be increased as a result of this.

Very truly yours,

CARBOLOY COMPANY, INC.

W. G. Robbins
President

WGR:GJG

ALL CONTRACTS AND AGREEMENTS SUBJECT TO STRIKES, ACCIDENTS AND OTHER CAUSES BEYOND OUR CONTROL. NO CLAIMS ALLOWED UNLESS MADE WITHIN FIVE DAYS AFTER RECEIPT OF GOODS. PRICES SUBJECT TO CHANGE WITHOUT NOTICE UNLESS OTHERWISE SPECIFIED.

WIRE & WIRE PRODUCTS, Vol. 12, No. 10, October, 1937, Executive office, 17 East 42nd St., New York, N. Y. Published by the Quinn-Brown Publishing Corp., Richard E. Brown, President; R. S. Spengel, Secretary and Treasurer. Publication office, 13 West Church Street, Washington, N. J. Subscription price: U. S., $5.00; Canada, $5.00 per year, 50 cents per copy; Foreign, $7.50 per year. Entered as second class mail at the Post Office, Washington, N. J., under Act of March, 1879.

## For Steel Anaiysis . . .

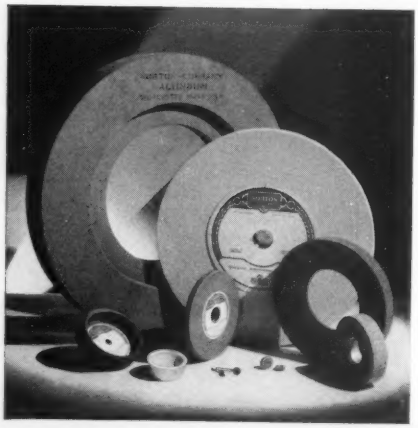
### *Norton Combustion Boats and R R Alundum Grain*

IN the plants of both the wire maker and the wire user, careful and frequent steel analyses are important. For years Norton Combustion Boats and RR Alundum have been popular with metallurgists for carbon determinations. Three types of Combustion Boats meet different conditions and preferences—and save costs because of their long life.

## For Shaping, Grinding and Polishing Cemented Carbide Dies . . .

### *Norbide Abrasive*

NORBIDE Abrasive is the hardest material ever produced by man for commercial use. In the re-cutting of wire drawing dies it is showing remarkable savings. Because its cost is but a small fraction of that of diamond dust it can be used more generously. The result is a cutting action that is just as fast but at a greatly reduced cost.



## For All Grinding Jobs . . .

### *Norton Grinding Wheels*

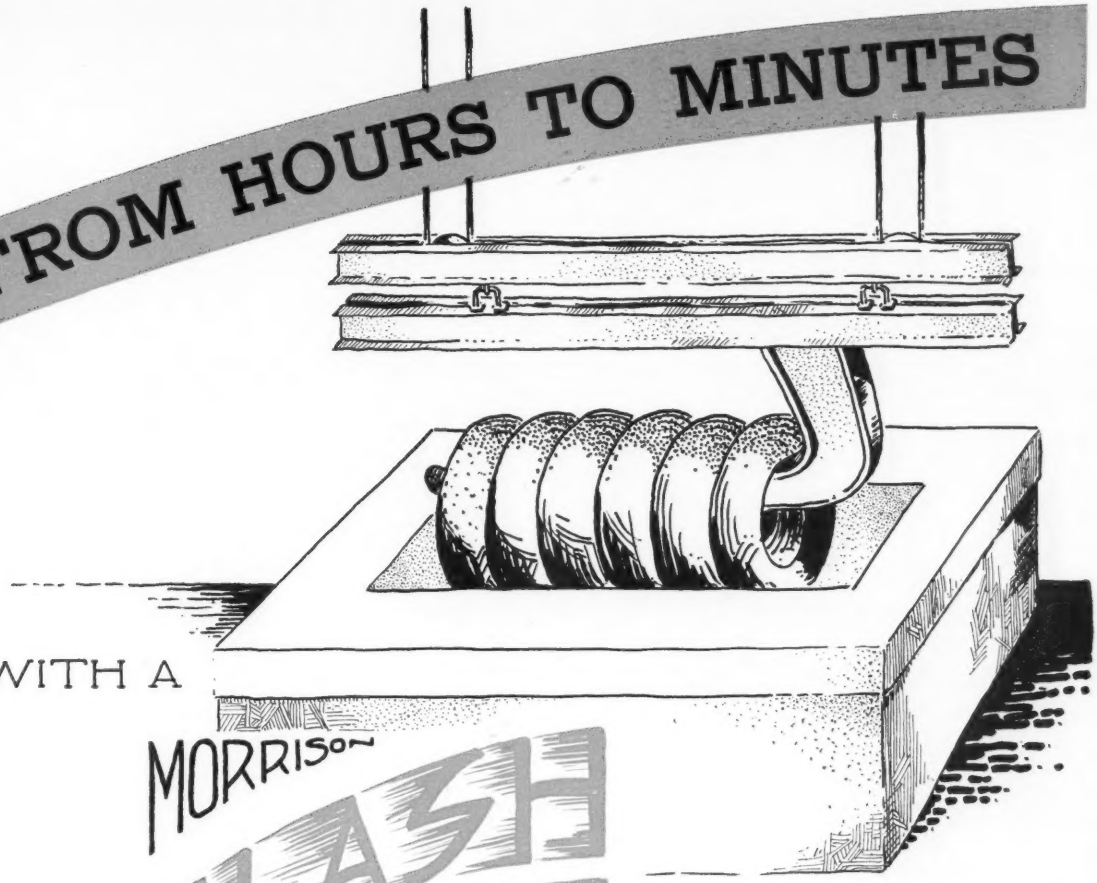
THE Norton line of wheels runs from tiny mounted points 3/32″ x 1/8″ to gigantic pulpstones six feet in diameter, 54″ wide and weighing ten tons. In the line are wheels for every grinding job in the wire industry—including special wheels for such operations as roll grinding, tool grinding, surfacing and internal grinding.

**NORTON COMPANY, WORCESTER, MASS.**

# NORTON ABRASIVES

W-617

# FROM HOURS TO MINUTES



WITH A

## MORRISON FLASH BAKER

Protected by U. S. Patent No. 1,999,513. Other Patents Pending.

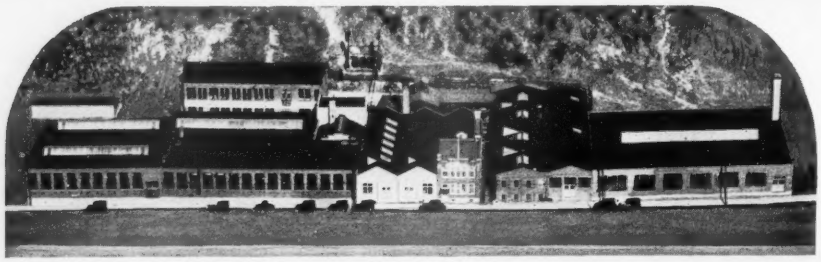
ROD baking has made amazing strides in recent months—strides in the direction of more profitable mill operation—major space savings, major fuel savings, major time savings! Space is saved by moving rod bakers to the cleaning house where they occupy approximately the area of a lime tank and become a part of the continuous cleaning process. Fuel is saved by thermal efficiencies that average 75,000 to 100,000 B.T.U. per ton of rod. Time is saved by baking periods that can range well below five minutes where such speed is required. Add to these economies, complete freedom from rusty rod, a very high degree of permanent recovery from acid brittleness, uniformity of drying regardless of the differing densities of the coil, and the fact that rod is never removed from the cleaning hook, and you have some of the paramount reasons for the all-around effectiveness of the new Morrison Flash Baker. We will welcome the mutual opportunity of telling you the complete story of these flash bakers in terms of your own special problems. Write for full details.

See a working model of the Morrison Flash Baker at our National Metal Exposition booth No. C-83.

MORRISON ENGINEERED

# MORRISON ENGINEERING CO., INC.

5005 EUCLID AVE . . . CLEVELAND . . . . . OHIO



# Fine Wires Finely Made

## HUDCO

Wires for Metal Spraying

Pure Lead
Lead Alloy
Pure Zinc
Zinc Alloy
Copper
Tin
High Brass
Low Brass
Solder Wire
Cadmium
Nickel Silver (10%, 18%, 30%)
Aluminum
Monel Metal
Phosphor Bronze
Pure Nickel
Commercial Bronze

* * *

High Conductivity Electric Wire

* * *

Brush Wires, Crimp and Straight (Brass, Steel, Nickel Silver, Copper and Phosphor Bronze)

## HUDCO

Fine Bare Wires

High Brass
Low Brass
Zinc 99.99 and High Tensile Zinc
Commercial Bronze
Phosphor Bronze
Pure Tin
Lead
Antimonial Lead
Cadmium
Nickel Silver, 10%, 18%, and 30%
Silver Plated Copper
False Gold and Special Brass and Bronze Alloys to Specification

* * *

Tinsel Lahns, Silver Plated Copper, False Gold and Copper

* * *

Metallic Fibre For Packing Purposes, Copper, Bronze, Zinc, Lead and Aluminum

## WINCO

Leakproof Enameled Wires drawn from special oxygen-free copper. There are no oxide inclusions which produce surface defects such as slivers. Perfect enameling is assured. Every foot is mercury-tested before shipment.

* * *

The Winco line of wires also includes enameled wires in all standard and special coverings made to meet exacting requirements.

* * *

Samples of Leakproof and other Winco Enameled Wires sent on request.

## HUDSON WIRE COMPANY

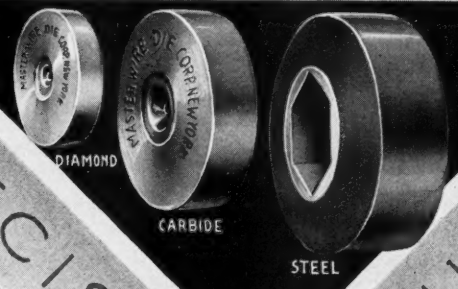
OSSINING, N. Y.

ESTAB. 1902 — Successors ROYLE & AKIN — ESTAB. 1902

# Complete Service to the Wire Drawer

# MASTER

ADVANCEMENT




PRECISION ACCURACY

Diamond Dies, Tungsten Carbide Dies, Steel Dies, Die Testing Instruments, Die Making Machinery . . . seemingly everything the Wire Drawer needs is made available by MASTER. The wide variety of products which MASTER manufactures enables the Wire Drawer to concentrate ALL his purchases from a single reliable source.

All MASTER Dies, Instruments, and Machinery are of uniform high quality assured by strict supervision and control over every process from start to finish. Through excellent service and progressive efficient operation, MASTER has steadily grown until today it is recognized as one of the leading Wire Drawing Die manufacturers in America.

## MASTER WIRE DIE CORPORATION

408 CONCORD AVENUE

NEW YORK, N.Y.

*Choose and Use*

# *BELL-MINE ROTARY KILN PULVERIZED LIME*

**Shipped in tight steel drums or in multi-wall paper bags (C. L. or L. C. L.)**

***For Longer Die Life***

***For Greater Adhesion***

***For a Smooth Rod Coat***

***For Greater Putty Yield per Unit of Lime Slaked . .***

## Warner Company

BELLEFONTE DIVISION

BELLEFONTE, PA.

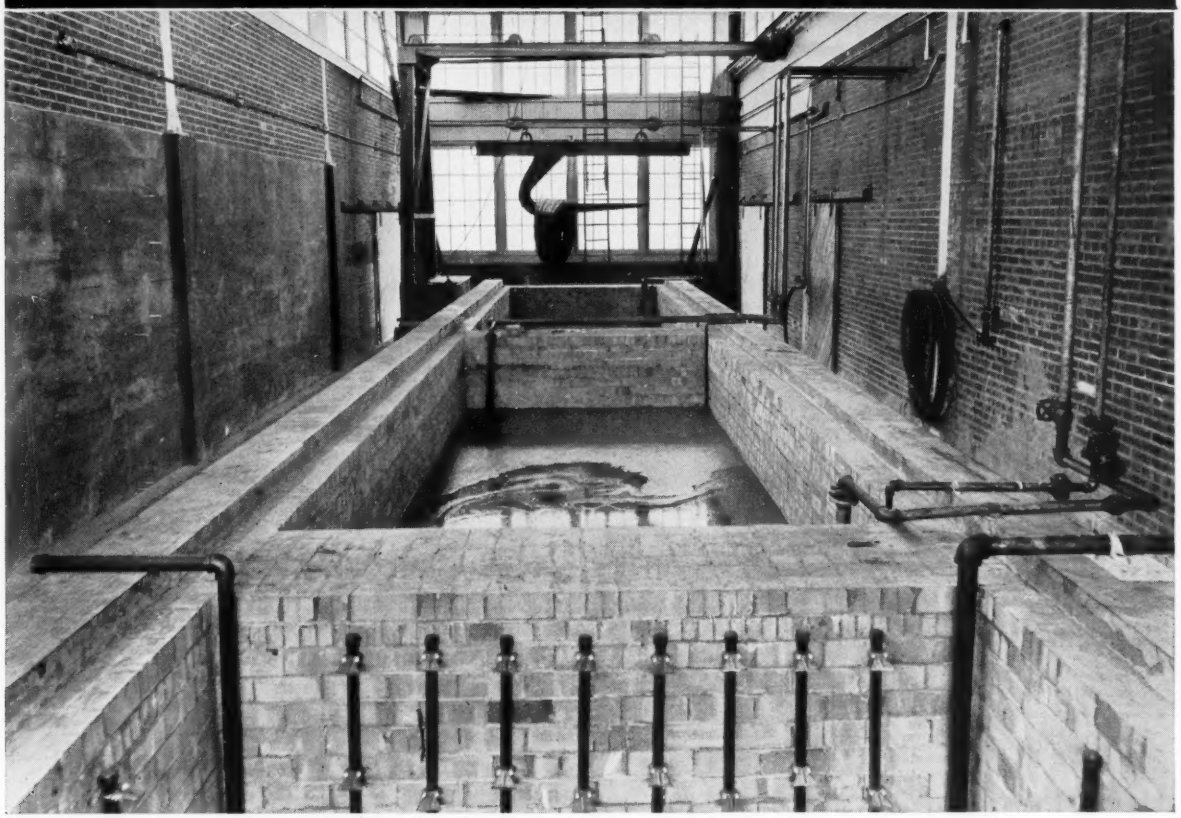
**Manufacturer of Bell-Mine Lime Products**

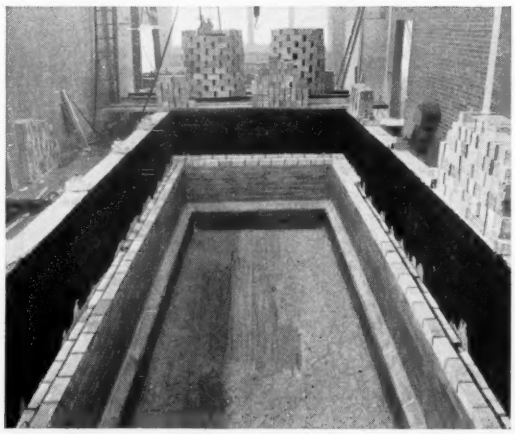
•

**At the Hotel Ambassador, Headquarters for the 1937 Meeting and Exhibition of the Wire Association, Oct. 18-21, consult our MR. R. L. HAMAKER, for information or quotations.**

•

# BASOLIT PICKLING TANKS





THE above picture shows two acid pickling tanks together with rinse tank, installed October, 1936, in the new cleaning house of the wire mill of the Buffalo Bolt Company at North Tonawanda, N. Y.

At the left the tanks are shown under construction—outer concrete shell, a layer of Nukem Asphalt Cement with inner lining of acid proof brick and acid proof jointing cement BASOLIT.

The installation illustrated is one of many hundreds where BASOLIT has contributed toward long life and efficient operation of modern pickling equipment.

**NUKEM PRODUCTS CORP., Buffalo, N.Y.**

NEW YORK PITTSBURGH DETROIT KITCHENER, ONT.

**BALLOFFET** is more than a name to the world of wire drawing. It is the institution wherein the greatest diamond drillers and die makers are assembled . . . their art, beyond that acquired in a single lifetime . . . ever increasing as it has been passed on from father to son. Since 1870 the wire drawing industry has learned to depend upon Balloffet to produce diamond dies ahead of the progress of wire making.

B A L L O F F E T

*Quality Diamond Dies Since 1870*

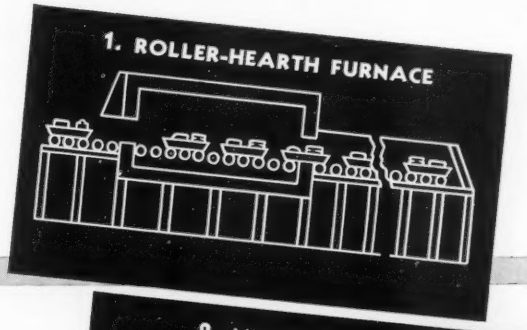
*Balloffet Diamond Dies are known and sold in every wire drawing country of the world. Different types and shapes of dies to meet every requirement.*

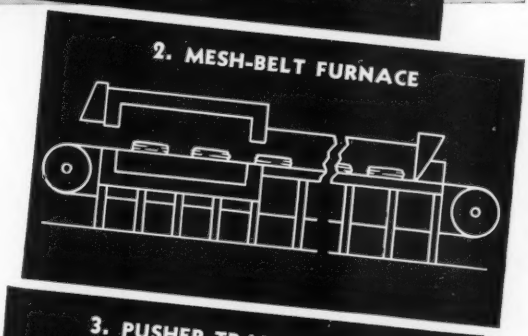
BALLOFFET DIES & NOZZLE CO., Inc.

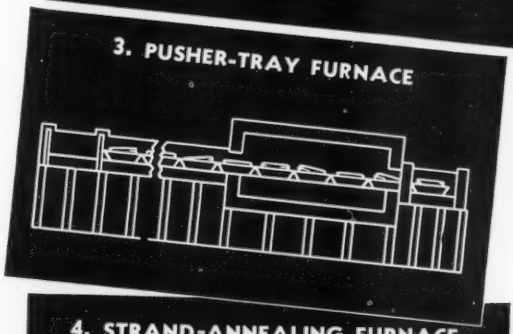
*45-47 Adams Street . . . Guttenberg, New Jersey*

# WHICH OF THESE FURNACES for Your Nonferrous Annealing?

**Read these descriptions of the five main types used and weigh the advantages of each.**



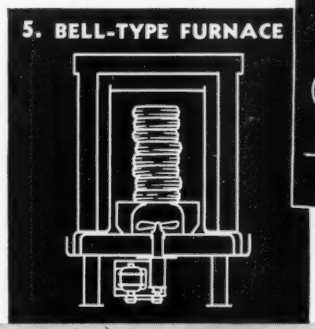
**1** **Roller-hearth furnace.** Excellent for annealing tubes in straight lengths, or work loaded in trays as in a pusher-tray furnace, this type has the advantages of greater production and lower maintenance costs. Since the lightest kind of trays can be used on the driven-roll conveyor, heat is conserved for doing useful work. As in the other furnaces discussed here, controlled atmosphere precludes the formation of scale.

**2** **Mesh-belt furnace.** This type is well suited for small parts, stampings, tubes, or light coils of wire. No trays are needed. The conveyor belt travels at constant speed according to the rate selected. Thus each part is treated for the same time under the same conditions, and the product is uniform—bright and scale-free.

**3** **Pusher-tray furnace.** Low original cost as compared to other continuous furnaces for annealing nonferrous stampings, coiled wire, or wire on reels. Loading and discharge chambers effectually preserve the controlled atmosphere while the work is being pushed, a tray length at a time, through the furnace.

**4** **Strand-annealing furnace.** Annealing wire is easy and effective with this equipment. A tube extending through the furnace acts both as a heating and a cooling chamber. A prepared atmosphere in the tube protects the wire from scaling or discoloration as it unwinds from one reel, passes through the furnace, and rewinds on another reel.

**5** **Bell-type furnace.** This electric batch-type furnace has proved to be the ideal equipment for the dry, bright-annealing of copper strip or of copper wire on reels or in coils. Several bases are used with each furnace so that, while one load is being heated, others are cooling and still others are waiting to be heated. Operation in this way is very economical.




For more information about these furnaces, or about equipment for other processes, call the nearest G-E sales office or write General Electric, Schenectady, N.Y.

**GENERAL ELECTRIC**

Filing No. 8716

170-65

FOR ✦ ✦ ✦

# WIRE TO ✦ ✦ ✦

# GAUGE AND FINISH!

## Use Detroit Diamond Dies Mounted In Monel Metal Casings

— ✦ ✦ ✦ —

OUR Diamond Wire Drawing Dies are all mounted in monel metal, preventing all slipping or loosening of the die in the casing.

— ✦ ✦ ✦ —

ALL dies are guaranteed as to gauge and finish. Satisfactory performance warranted.

— ✦ ✦ ✦ —

TO take care of our rapidly expanding business, we have established a New York branch office in the Graybar Bldg., 420 Lexington Avenue. A branch manufacturing plant will also be established in the vicinity of New York.

— ✦ ✦ ✦ —

YOUR inquiries will receive prompt attention.

— ✦ ✦ ✦ —

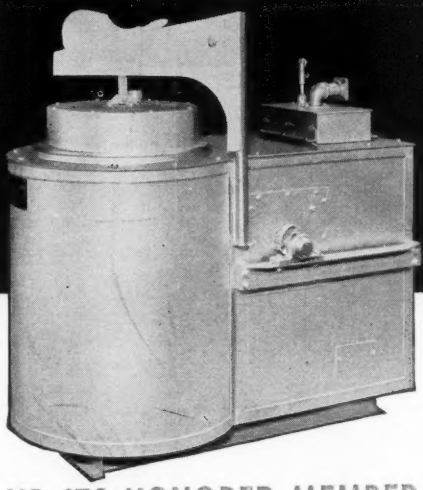
## DETROIT WIRE DIE COMPANY

OFFICE
1956 Graybar Bldg.,
420 Lexington Ave.,
New York, N. Y.

FACTORY
Fort Wayne, Ind.

OFFICE
17360 Lashier Ave.,
Detroit, Mich.

# The LINDBERG Line



Cyclone Tempering Furnace — Electric and Gas Fired

77.3%
15.9%
93.2%

AND ITS HONORED MEMBER

CYCLONE

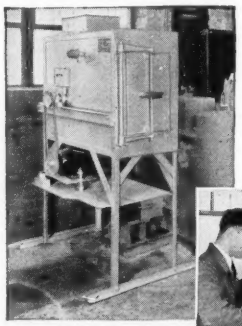
## HEAT TREATERS AWARD

**CYCLONE FIRST PREFERENCE**

was accorded the astounding preference of 93.2% in a recent broadcast survey.

That it achieved such popularity in the short space of 2½ years on the market, is a tribute of the trade to the splendid performance of this experience-built furnace . . . and this spontaneous acceptance is shared by every member of the Lindberg line.

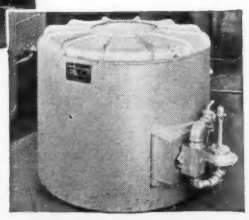
Full details of the survey and other proofs of Lindberg performance will be furnished at the Metal Show (Booth A-67) . . . or sent on request. Be sure to ask for them.



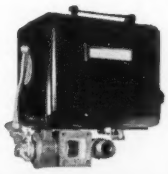
Box Type Cyclone for Toolroom Service

Laboratory Cyclone Furnace For Small Parts

**BOOTH A-67**



Screw Type Pot Furnace Spiral Flame Travel



Throttling Control for Gas Fired Furnaces

Lindberg Control For Electric Furnaces

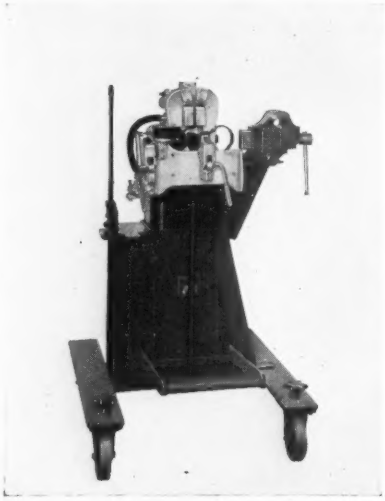
**Lindberg Engineering Co.**

223 N. LAFLIN STREET — *Offices in Principal Cities* — CHICAGO, ILLINOIS

*Canada—Williams & Wilson, Ltd.*

# A WELDER FOR EVERY PURPOSE

MICROMETER PRECISION — MICRO-WELD — TRADE MARK REG. U. S. PAT. OFF.



Micro Model "J-5" and "J-6" With Dial Indicating Attachment. For Welding and Annealing High Carbon Wire.

THERE is positive control of annealing temperatures and already hundreds of these special MICRO-WELDERS are proving their dependability and satisfactory performance with leading manufacturers.

✦ ✦ ✦

RUGGED construction that endures severe operating conditions assures definite results easier — quicker — over a longer period.

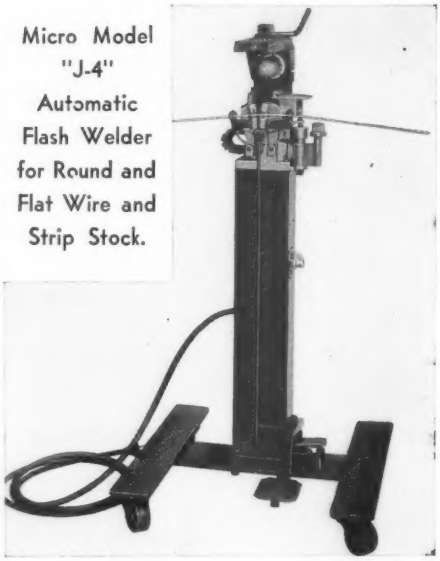
✦ ✦ ✦

SIMPLICITY of operation is your best guarantee of uniform consistent work.

✦ ✦ ✦

IF you manufacture or fabricate wire, you can profit by using MICRO WELDERS.

✦ ✦ ✦



Micro Model "J-4" Automatic Flash Welder for Round and Flat Wire and Strip Stock.

Micrometer Precision — MICRO-WELD — Trade Mark Reg. U.S. Pat. Off.

MICRO-WELDERS with dial indicating annealing attachments are now available for high carbon wire.

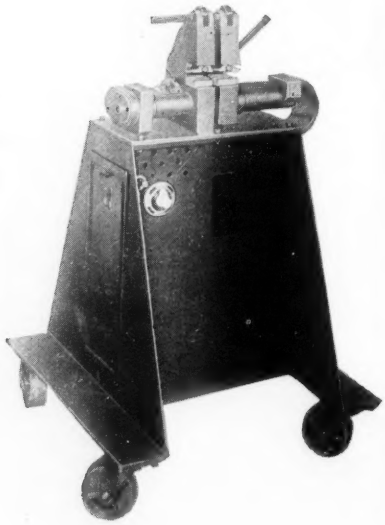
✦ ✦ ✦

Only MICRO-WELDERS are equipped with the patented MICRO-WELD adjustment dials for making precision welds faster.

✦ ✦ ✦

LOOK for the MICRO WELD symbol of proven success over the widest range of operations.

✦ ✦ ✦



Micro Model "T" General Purpose Butt Welder for fast, accurate heavy-duty service.

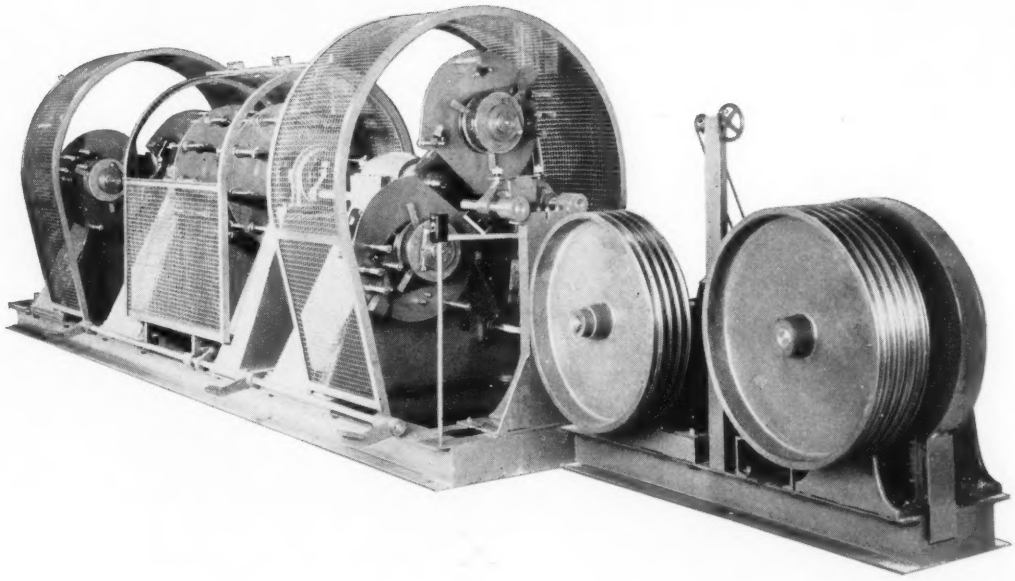
Ask us about your welding problems and we'll tell you what MICRO can do for you.

## MICRO PRODUCTS COMPANY

20 NORTH WACKER DRIVE, CHICAGO, ILL.

Telephone State 7468 — General Office and Factory, Peoria, Ills.

# New Service Entrance Cable Machine



This machine was developed to produce service entrance cable. The cable consists of one and two conductors covered with 2 paper tapes, 42 endsof copper for the neutral conductor, and 2 rubber tapes.

The machine is designed with taping heads of the eccentric type for applying both the paper and rubber tapes. These heads will handle packages of tape 16″ diameter up to 3½″ wide.

The wire head will carry 42 reels, 6″ diameter by 6″ traverse, weighing approximately 25 lbs. each.

Both the taping heads and wire heads are supported on heavy cast iron pedestals which entirely enclose all drives, including P. I. V. speed controls.

The double capstans, 30″ diameter, with grooved faces, are controlled through a P. I. V. variable speed unit.

The machine is equipped with ball bearings throughout, and is provided with guards on all revolving parts. The drive is through five V-belts from a 7½ HP motor which is completely wired to the magnetic switch and three stop-and-start push button stations. The brake is of the mechanical type, foot operated.

We can also make these machines in any combination desired.

A complete description and specifications with prices will be supplied on request.

## NEW ENGLAND BUTT COMPANY

**Chicago Office**
**20 NORTH WACKER DRIVE**

**Main Office and Plant**
**PROVIDENCE, R. I.**

# Hubbard Spool Company

*Extends Greetings to the*

*Members of the*

# Wire Association

*Here's to a Successful*

*Meeting!*

# Hubbard Spool Company

1622 Carroll Avenue
Chicago, Ill.

TELEPHONE SEELEY 4554

# When it's a question of RODS

WHETHER tonnage requirements are large or small, wire manufacturers find Bethlehem a dependable source of rod supply for virtually all types of wire. Bethlehem's rod mill is geared to meet promptly the requirements of individual manufacturers and to be ready to supply the exact grade of rod desired.

Bethlehem Rods are manufactured in three general classifications: basic open-hearth and Bessemer in low- and medium-carbon ranges, and basic- and acid-open-hearth in higher carbon ranges. Rods in all analyses are made within these general classifications, providing material for wire of practically every description.

BETHLEHEM STEEL

**BETHLEHEM STEEL COMPANY**

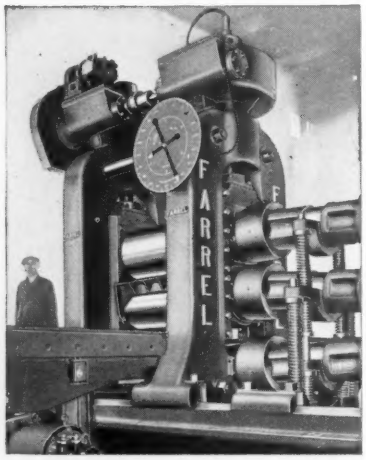
FARREL
REG. U.S. PAT. OFF.

# ROLLING MILL MACHINERY

ROLLING MILLS — For non-ferrous metals, foils and cold strip steel. Complete rod mills from furnace to coilers.
ROLLS—All sizes for various purposes. Chilled Iron, Special Alloy Iron, Steel.
UNIVERSAL MILL SPINDLES
ROD MILL TABLES AND MANIPULATING EQUIPMENT
ROD COILERS
LEAD PRESSES FOR PIPE OR ROD
ROLL GRINDING MACHINES
ROLL CALIPERS
CINDER CRUSHERS
GEARS
MILL PINIONS
PINION STANDS
DRIVES UP TO 10,000 H. P.
FLEXIBLE COUPLINGS

## ROLLING MILLS

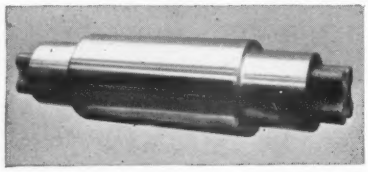
Farrel Rolling Mills are built in a wide range of sizes, designed for any specific purpose and constructed with the greatest care to insure precision. Improved design and construction provide many advanced features which bring about higher operating efficiency, increased output, lower power consumption, minimum labor and maintenance costs and improved quality products.




Our engineers will be glad to explain in detail the design features and operating advantages of Farrel Rolling Mills as applied to your particular conditions. A conference involves no obligation and may develop data relating to plant layout, operation, costs, etc., which will be helpful in making comparisons with present equipment and methods in the selection of new equipment for greater operating efficiency and economy.

## ROLLS

Over seventy-five years' experience in designing and manufacturing rolls for a broad variety of uses, unexcelled plant facilities, modern equipment, skilled technicians in metallurgy and engineering, founders and machinists trained in specialized roll manufacture, make an effective combination for producing rolls of superior quality, precision and durability.

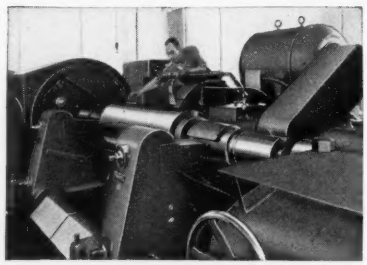


Farrel Rolls are made in several grades, including Cupola and Electric Furnace Chilled and Alloy Iron, Heat-Treated Farrel Ni-Hard, and Steel.

Farrel Ni-Hard Rolls combine a hardness of 85 to 90 with high strength and a flawless surface. They are ideal for high finish sheets as they produce a higher quality finish, their life is longer and cost per ton of output is lower.

## ROLL GRINDERS

Farrel Heavy Duty Roll Grinders are designed for better, faster and cheaper grinding to the extreme limits of accuracy required by modern rolling mill practice. Equally capable of heavy roughing or fine finishing. Crowning device produces mathematically correct crown or concavity, exactly symmetrical on both halves of the roll. Smooth, vibrationless work drive through multiple V-belt



driven headstock. Centralized control at operator's station. Combination of all features assures high quality of work with maximum production.

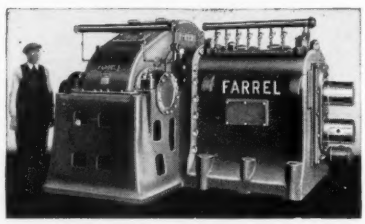
Built in six standard sizes to handle rolls up to maximum diameters of 24", 28", 36", 44", 52" and 60", and lengths from 8' 0" to 26' 0" between centers.

## GEAR DRIVES

Farrel Heavy Duty Mill Drives are designed by engineers with a thorough understanding of the conditions imposed by the higher speeds and heavier loads encountered in modern rolling mill operation.

The drives are scientifically proportioned, with large factors of safety, and are built of carefully selected materials, designed to provide maximum strength and rigidity. The continuous tooth herringbone gears are accurately generated by the Sykes process. Advanced features of design assure high efficiency, smooth, quiet operation, trouble-free service and long life.

Available in single, double and multiple reduction units, for high or low speeds, any power up to 10,000 H.P., with integral pinion stands or other special arrangements.

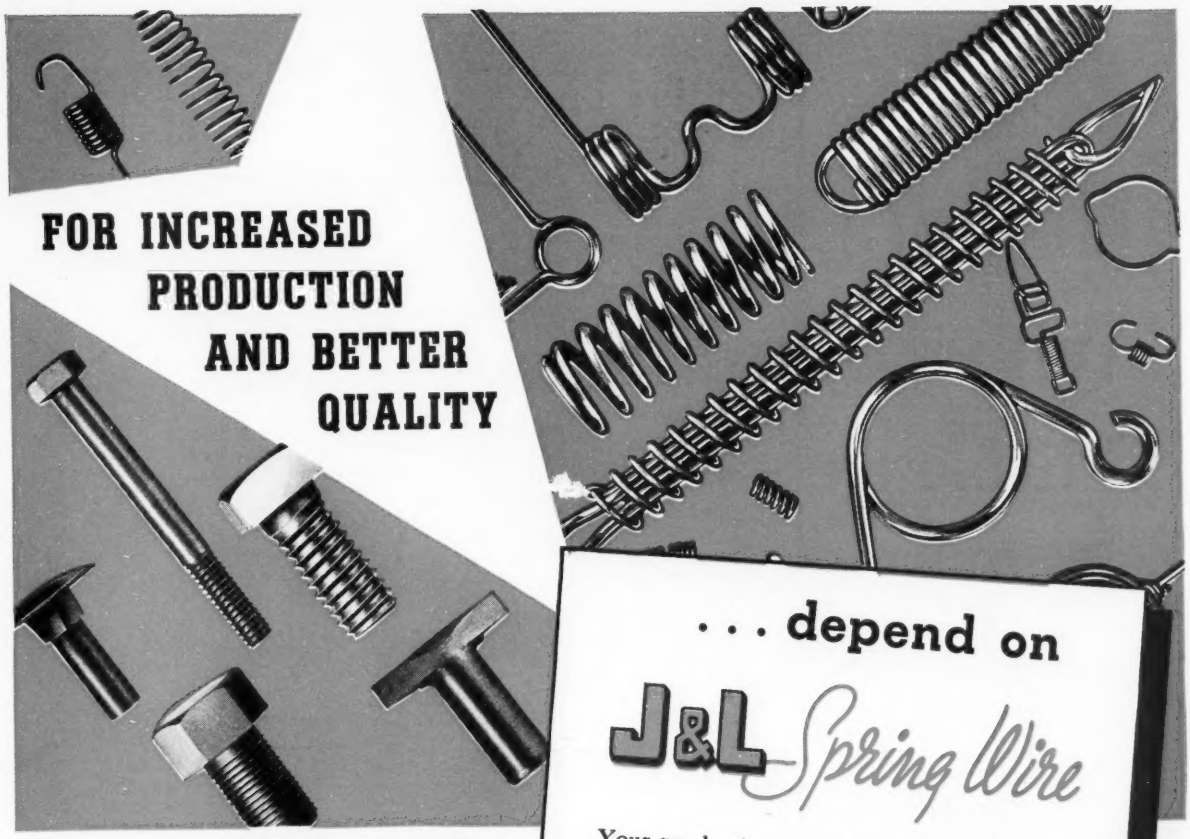



## FARREL-BIRMINGHAM COMPANY, INC.

38 Main St., Ansonia, Conn. 327 Vulcan St., Buffalo, N. Y.

NEW YORK ● PITTSBURGH ● AKRON ● CHICAGO ● LOS ANGELES

**NEW RECORDS FOR PRODUCTION AND PRECISION ARE MADE ON FARREL-BIRMINGHAM MACHINES.**



# FOR INCREASED PRODUCTION AND BETTER QUALITY

## . . . depend on J&L Spring Wire

Your production speeds up with J&L Spring Wire . . . because this superior spring wire lends itself readily to coiling, crimping, knotting, and other forming operations.

And you get the added benefit of the uniformly high quality springs you need to build good will and increase sales. Built into J&L Spring Wire is the resilience to provide just the right springiness, and the rugged stamina to hold that springiness indefinitely.

Because of this, hundreds of manufacturers use Jones & Laughlin Spring Wire . . . knowing from past experience that this wire gives them better springs at lower cost.

You, too, will find that J & L Spring Wire will speed your production and increase your profits. Specify Jones & Laughlin on all your orders.

## . . . depend on J&L Cold Heading Wire

Greater output, fewer rejects, and better quality finished parts . . . these are profit-making advantages that you get with J&L Cold Heading Wire.

The high quality . . . and the uniformity of J&L Cold Heading Wire . . . help to lower manufacturing costs.

See for yourself how its quality, accuracy, uniformity of size, give you increased production . . . better parts . . . bigger profits. Try Jones & Laughlin Cold Heading Wire in your operations.

INCREASE YOUR PROFITS WITH J&L STEEL

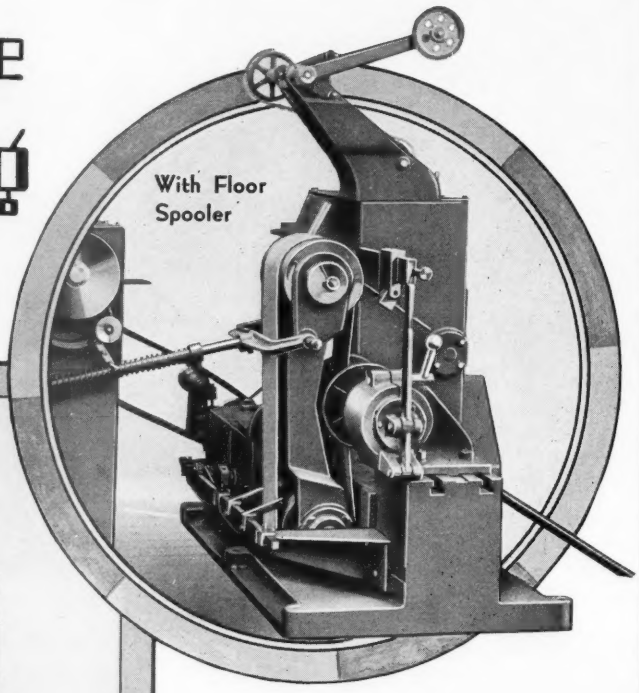
**JONES & LAUGHLIN STEEL CORPORATION**

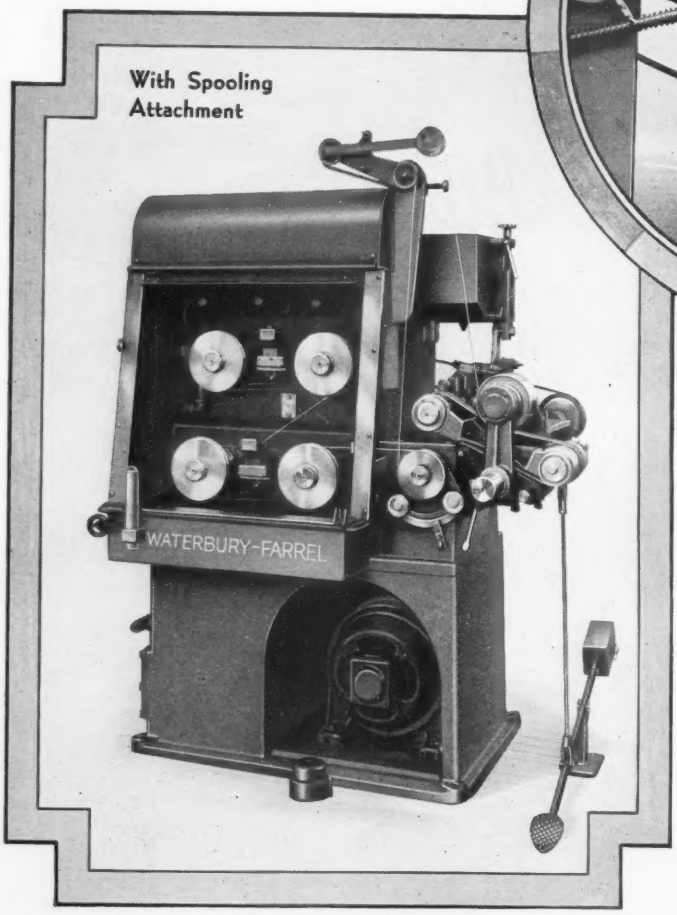
PITTSBURGH, PENNSYLVANIA

MAKERS OF HIGH QUALITY IRON AND STEEL PRODUCTS SINCE 1850

# Waterbury-Farrel

## Upright Cone Wire Drawing Machines . . .


With Floor Spooler



With Spooling Attachment

## HIGH SPEED

These high speed machines are built in four standard sizes and are intended primarily for copper wire. We illustrate the drum type construction with spooler.

Similar machines with adjustable block and reversing mechanism are available. These have been designed especially for brass and other non-ferrous alloys.

For further particulars consult our Engineering Department.

**The Waterbury Farrel Foundry and Machine Co.**

**HOME OFFICE AND WORKS: Bank and Meadow Sts., Waterbury, Connecticut**

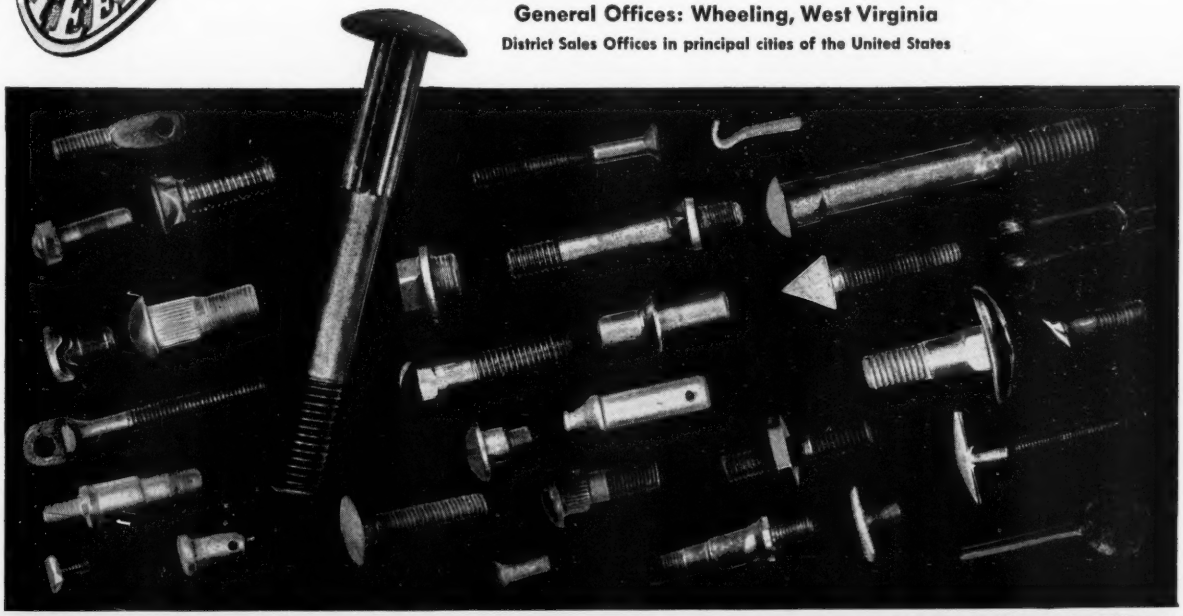
CLEVELAND CHICAGO NEWARK, N. J.

WHEELING puts emphasis on quality through every step of rod and wire manufacture . . . and quality is assured the fabricator. Wheeling facilities, and Wheeling control of these facilities, are thorough and complete.

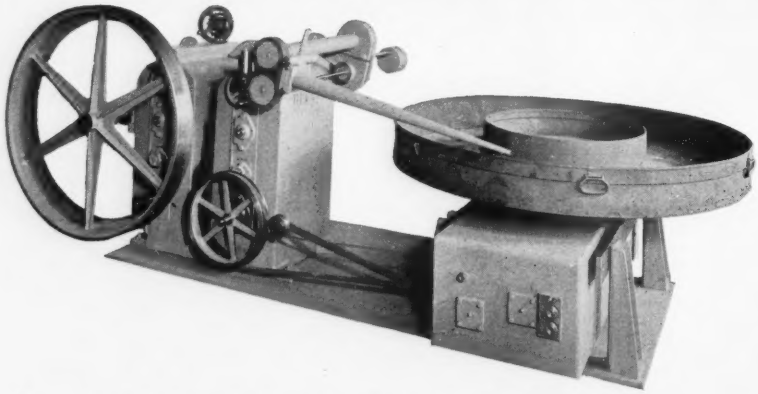
**WHEELING STEEL CORPORATION**

General Offices: Wheeling, West Virginia

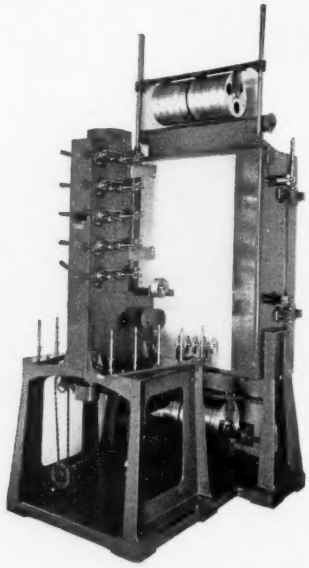
District Sales Offices in principal cities of the United States



**IT'S WHEELING STEEL**

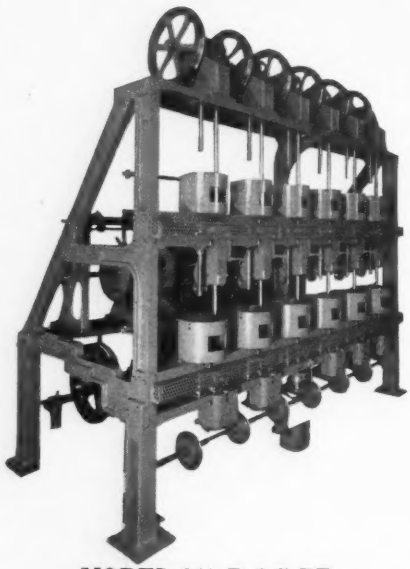


**AIMCO AUTOMATIC PANNING MACHINE**
**for Rubber Covered Wire, Ball Bearing**

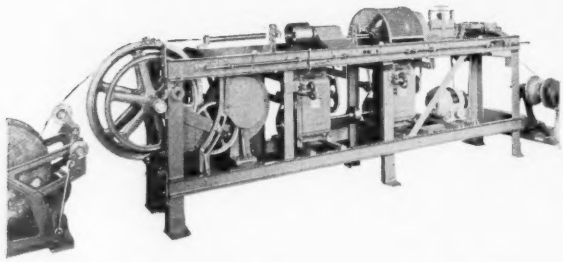


**MODEL M-10 FINE WIRE ENAMELING MACHINE**
**Ball Bearing, Motor Drive.**

EST. 1855 AIMCo INC. 1915
"American" INSULATING MACHINERY COMPANY
517 West Huntingdon St.
PHILADELPHIA PENNSYLVANIA U.S.A.

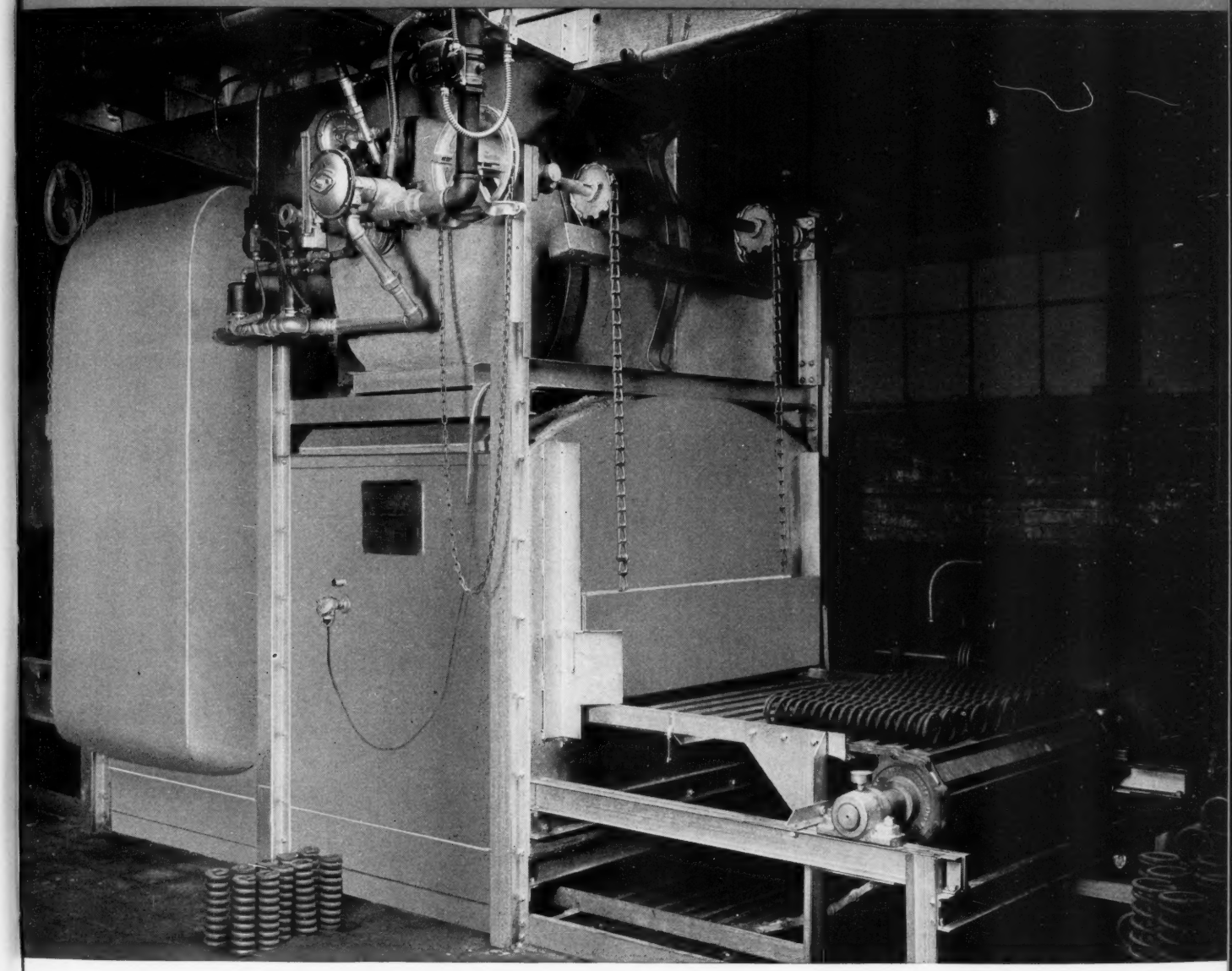


**MODEL 2½ D-6 S BB**
**INSULATION WINDING MACHINE**
**For Application of Paper Tape or Cotton.**
**High Speed, Ball Bearing, Motor Drive.**



**MODEL 4-T-1 T BB**
**INSULATION WINDING MACHINE**
**For Application of Two Paper Tapes and One Cotton Binder.**
**High Speed, Ball Bearing, Motor Drive.**

# AIR DRAWING SPRINGS BY THE MOST MODERN METHOD



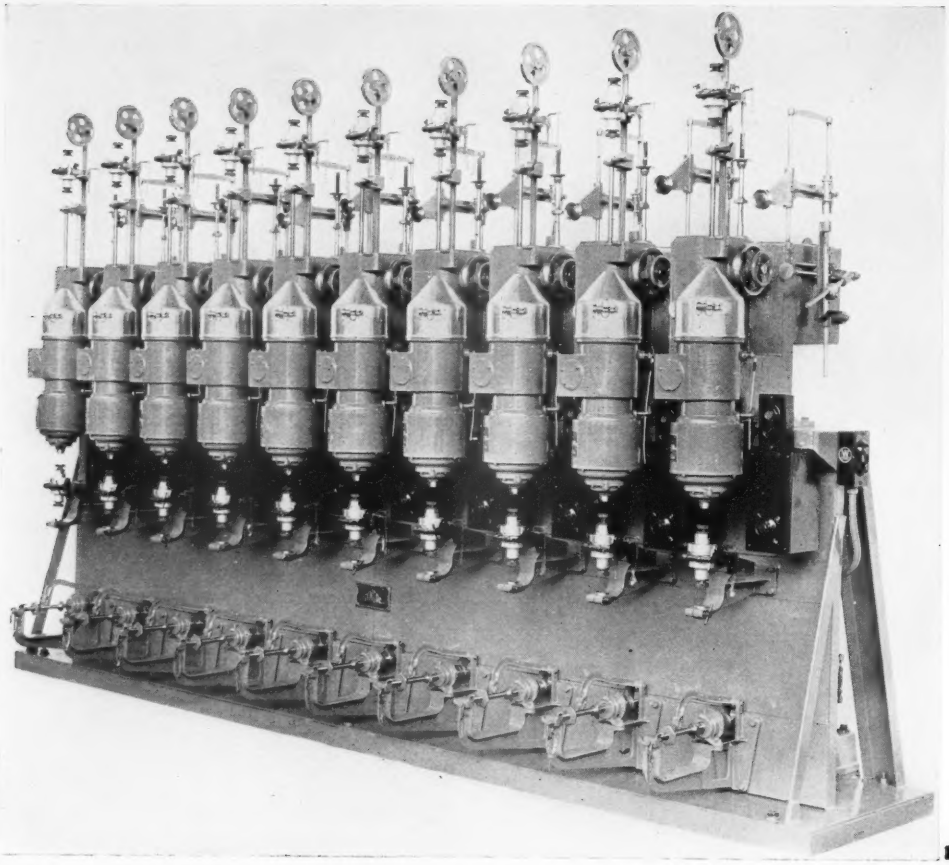
● Surface Combustion air heaters are finding many applications in industry. Hundreds are used by one of the large motor car builders for providing warm air curtains on spray painting lines and for heating the drying ovens. Here is shown an SC Air Heater as an integral part of an SC gas-fired continuous air draw furnace in a coil spring manufacturing plant. Large springs are loaded directly on the conveyor as shown. Small springs are loaded in tote boxes holding an average net load of 200 pounds. The capacity of the furnace is 2000 pounds per hour and the temperature range 500 to 1000° F.

For low cost drawing operations, the SC air draw furnace provides the most efficient unit for production. Compact, modern, carefully engineered — the SC standard air heater may be used with existing furnaces or made an integral part of a new one. Ask SC engineers in to discuss your heat treating problems.

SURFACE COMBUSTION CORPORATION, Toledo, Ohio

SURFACE COMBUSTION

*Builders of* ATMOSPHERE FURNACES and HARDENING, DRAWING, NORMALIZING, ANNEALING FURNACES for CONTINUOUS or BATCH OPERATIONS



# ANNOUNCING . . . .

## SYNCRO Fine Wire Insulating Machines

All the advantages of previous "Syncro" models, such as extreme accuracy, high speed, flexibility, economy and efficiency are incorporated in the new "Syncro" Fine Wire Insulating Machines.

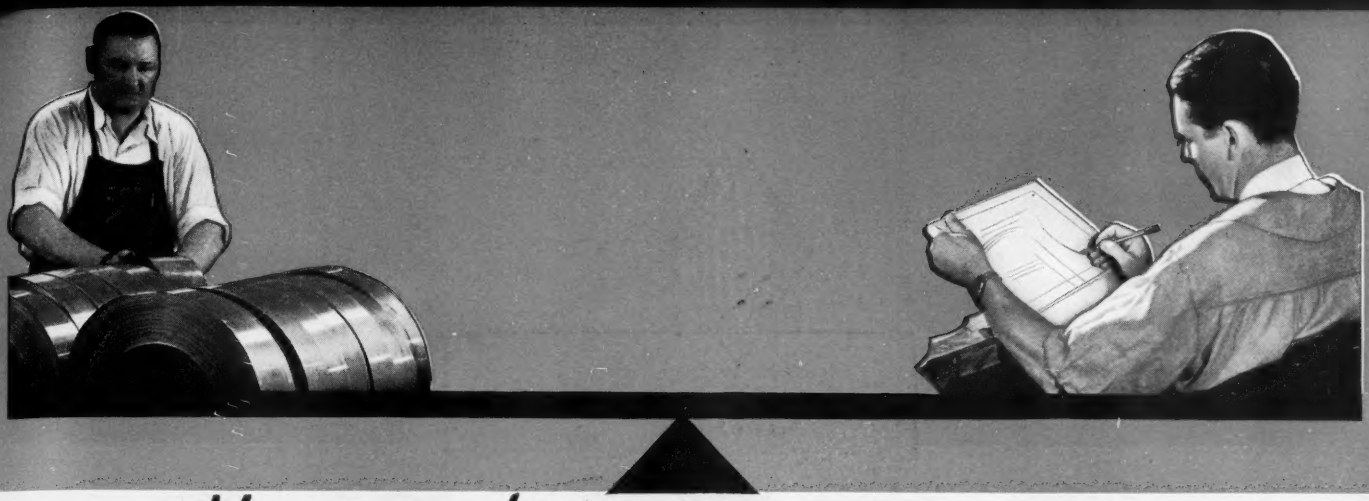
Visit space F-2 at the Convention for a demonstration of the unusual performance of "Syncro" Fine Wire and other models of "Syncro" Insulating Machines, or write for complete details.

SYNCRO MACHINE COMPANY

187 Sylvan Avenue Newark, N. J.

SYNCRO INSULATING MACHINES

ACCURATE FAST ECONOMICAL EFFICIENT



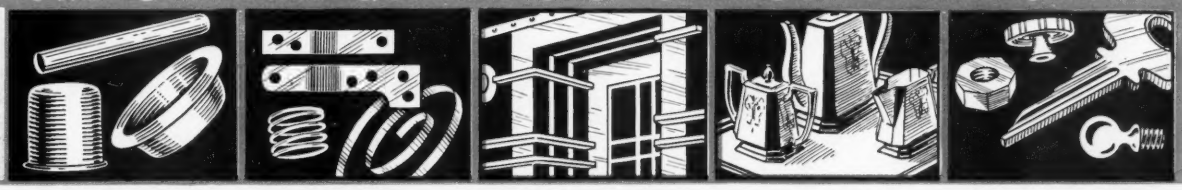
# *Material* IS AS IMPORTANT AS DESIGN

In product development, *material* is just as important as design. Failure to sense this has prevented public acceptance of many a good basic idea. Every detail of a machine or appliance should be as nearly right as expert engineering can make it—and to place performance or appearance at the mercy of doubtful material, to save a few cents here and there, may turn out to be not a gain but a loss—the game may not be worth the candle! Insurance against this is often the use of Seymour Nickel Silver or Phosphor Bronze instead of less dependable alloys.

## *Absence of any of the following qualities in a product*

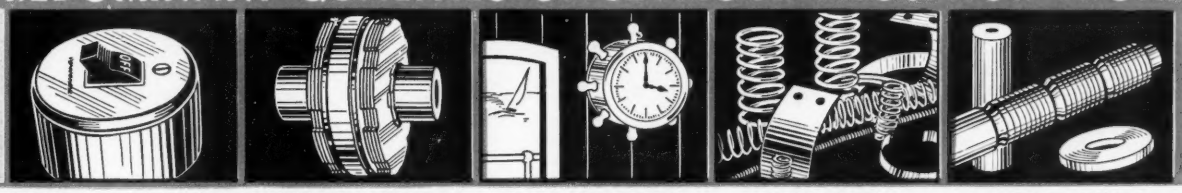
## CAN SERIOUSLY HANDICAP ITS CHANCES OF SUCCESS

### PREDOMINANT QUALITIES OF SEYMOUR NICKEL SILVER



DUCTILITY | TEMPER | NON-CORRODIBILITY | WHITENESS | MACHINABILITY

### PREDOMINANT QUALITIES OF SEYMOUR PHOSPHOR BRONZE



FATIGUE RESISTANCE | FRICTION RESISTANCE | NON-CORRODIBILITY | RESILIENCY | MACHINABILITY

SEYMOUR NICKEL SILVER—An alloy of copper, nickel and zinc. Its even grain makes it ideal for silver plating, and its silvery white color is scarcely perceptible when exposed by wear of plate. Ideal also for other plating, especially chromium, no underplate being necessary. It is capable of a wide range of hardness, from dead soft to a lively spring temper. In its ductile stages, it is superb for deep draws and difficult spinning. When properly leaded, it machines freely. In all its forms, it is practically corrosion proof.

SEYMOUR PHOSPHOR BRONZE—An alloy of copper, tin and phosphorus. Principal characteristics: non-corrodibility, toughness, and extreme fatigue and friction resistance. Subject to a considerable degree of hardness—therefore excellent for springs that must stand long, constant flexure. Practically indifferent to sudden thermal change, will not "arc" when charged or spark appreciably when struck. Very free cutting when leaded. Efficient in electrical instruments, and in all devices used in damp areas. (Test samples of either alloy on request.)

**THE SEYMOUR MANUFACTURING COMPANY, 62 FRANKLIN ST., SEYMOUR, CONN.**

# SEYMOUR

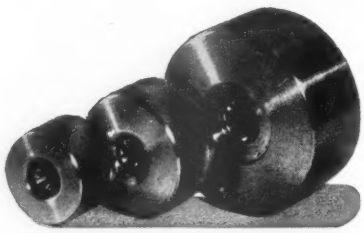
## NICKEL SILVER—PHOSPHOR BRONZE

### "CONTROLLED GRAIN" NICKEL ANODES

**EXHIBITING BOOTH F92, NATIONAL METAL CONGRESS, ATLANTIC CITY, OCT. 18-22**

DIAMOND DIES CARBIDE DIES
UNWIDIE
UNWIDIE

"Not a better die
but the best"



# UNWIDIES

STABILITY AND INTEGRITY ARE MAJOR ITEMS IN DIAMOND DIE PURCHASE.

WITH RISING LABOR AND MATERIAL COSTS A DIAMOND DIE GUARANTEE MAY BECOME A PITIFULLY SHRUNKEN THING.

WHEN YOU TIE UP YOUR GOOD DOLLARS YOU OUGHT TO KNOW THAT AMPLE PROVISION HAS BEEN MADE FOR GUARANTEE AND THAT WHATEVER IS PROMISED CAN BE PERFORMED.

THE LESSONS OF THE PAST ARE TOO QUICKLY FORGOTTEN.

ALWAYS REMEMBER THAT THE PRESENT IS HISTORY IN REPETITION AND THAT SAD EXPERIENCES OF MANY DIAMOND DIE USERS OF THE EARLY NINETEEN TWENTIES MAY BE REPEATED.

## THE UNION WIRE DIE CORPORATION

MAIN PLANT AND OFFICES — Stamford, Connecticut

BRANCHES:

11 West 42nd Street
New York, N. Y.

Montrogue, France

Paris, France

London, England

# WIRE AND WIRE PRODUCTS

A monthly publication devoted to the production of Wire, Rod and Strip, Wire and Rod Products and Insulated Wire and Cable

DRAWING—ROLLING—EXTRUDING—FORMING—FABRICATING

Vol. 12 OCTOBER, 1937 No. 10

Designated as

Official Publication By The Wire Association


## Contents


Abnormal Grain Growth and the Annealing of Low Carbon Steel Wire ..... By B. L. McCarthy 535

A Metallurgical Study of the Factors Affecting the Quality of Galvanizing ..... By R. W. Sandelin 545

A. C. Electro-Pickling - A Better Method of Pickling ..... By A. B. Dove 563

Lime in the Wire Industry ..... By D. E. Washburn 572

Fatigue Properties of Helical Springs ..... By R. R. Tatnall 577

The Manufacture of Fourdrinier Wires ..... By H. E. Brown 592

Developments in Cold Heading at General Electric ..... By A. R. Ryan 601

Cold Drawn Bars ..... By D. W. McDowell 609

"Double Treating" Track and Frog Bolts ..... By Chas. Fassinger 613

The Need of a Better Quality of Copper in Apparatus Manufacture ..... By L. H. Burnham 623

Production of Copper from Mine to Mill By W. H. Bassett, Jr. 629

Notes on the Annealing of Nickel Silver Wire in Coils ..... By T. C. Merriman 635

Nickel and Nickel Base Alloys in Wire and Rod Products ..... By C. Rolle 640

Exports and Imports of Wire ..... 654

Outstanding Personalities of the Wire Industry ..... 656

Wire Association Program ..... 659

Wire Association Membership List ..... 662

A Review of Recent Wire Patents ..... 669

'Round the World with the Wire Industry ..... 673

Index to Advertisers ..... 685

Buyers' Guide ..... 686 - 688



—ASSOCIATE EDITORS—

Kenneth B. Lewis, Consulting Wire Mill Engineer
W. H. Spowers, Jr., Consultant on Galvanizing
J. W. Rockefeller, Jr., Consulting Engineer for Springs and Wire Products
Lancaster, Allwine & Rommel, Consultants on Patent Information
European Correspondent
Paul Fidrmuc

Richard E. Brown, Business Manager



Executive and Editorial Offices:
17 E. 42nd St., New York City. Telephone: Murray Hill 2-4188

Publication Office: Washington, N. J.

Annual Subscription, U. S. $5.00, Canada $5.00

50 Cents a Copy Issued Monthly Foreign, $7.50



Copyright 1937, Quinn-Brown Publishing Corp. WIRE AND WIRE PRODUCTS is fully protected by copyright and nothing that appears in it may be reprinted wholly or in part without permission.



**Single Copies of Convention Issue $1.00**



# ANACONDA

## Copper and Copper Alloy Wire

**in all Commercial Tempers and Sizes including Round, Flat, Hexagonal and Special Shapes.**

• • •

## Resistance Wire

**Nickel Silver.**

• • •

## Weaving Wire

**"Antique" and "Golden" Bronze, Brass, Nickel Silver, Ambrac, Everdur, Phosphor Bronze, Copper and Fourdrinier Wire.**

• • •

## Spring Wire

**Brass, Phosphor Bronze, Everdur, Ambrac, Beryllium Copper.**

• • •

## Wire for Special Purposes

**Copper, Brass, Bronze, Everdur and Nickel Silver in special grades for the manufacture of rivets, nails, pins, piano hardware, etc. Fine wire on spools.**

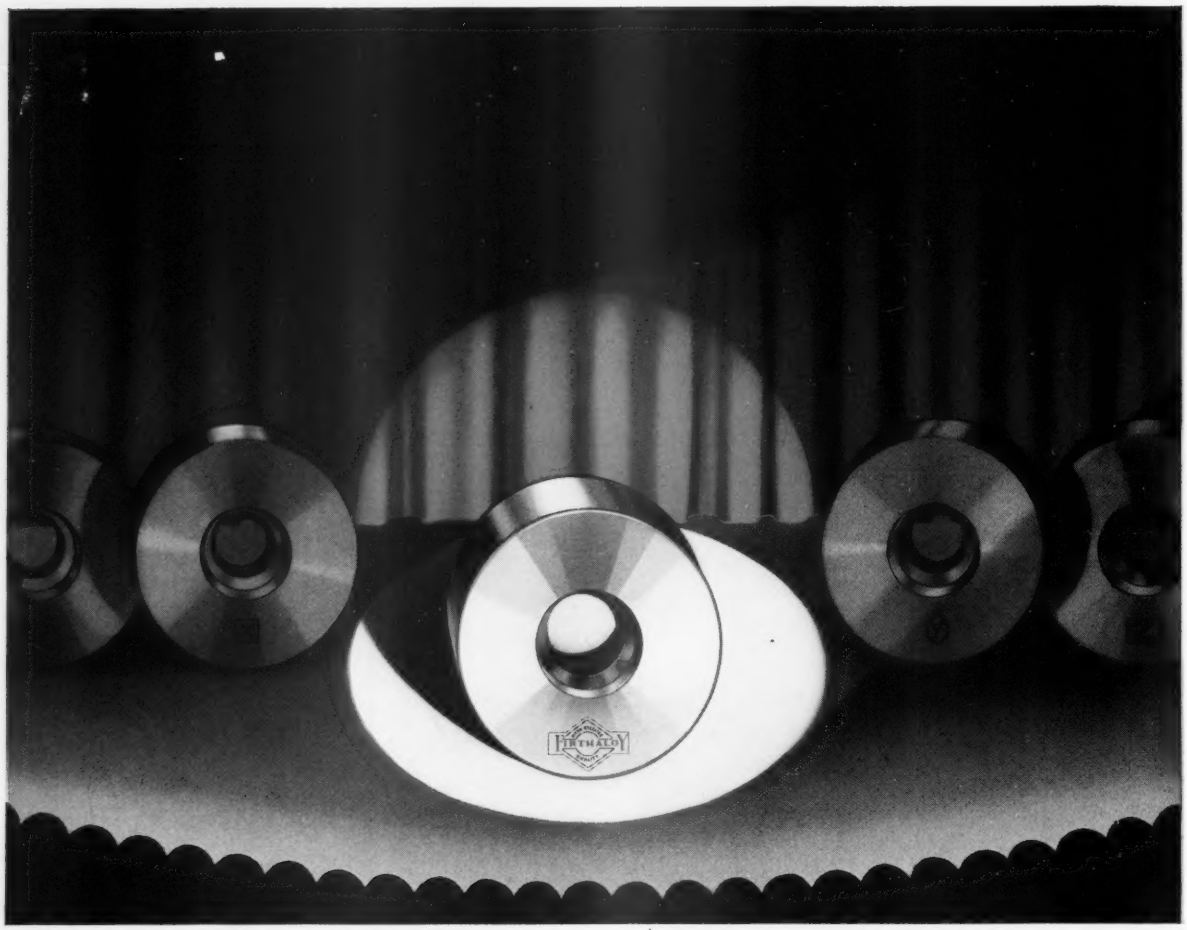
• • •

ANACONDA
from mine to consumer

## The American Brass Company

**General Offices: Waterbury, Conn.**

**Offices and Agencies in Principal Cities.**




# The Spotlight is on FIRTHALOY

On the industrial stage, the spotlight is on FIRTHALOY —a star performer. Recognition of extraordinary merit came quickly from a few friends but now has become general. Even the "critics" now praise FIRTHALOY because it can be relied upon for day to day consistently superior performances.

Whether the desired performance be drawing wire, rod, or tubing, you can count on—FIRTHALOY. Insist on the trademark on every die.

**FIRTH-STERLING STEEL COMPANY**

Works: McKEESPORT, PA.
NEW YORK CHICAGO HARTFORD
CLEVELAND DETROIT LOS ANGELES
PHILADELPHIA DAYTON
GLOBE WIRE DIVISION, McKEESPORT, PA.

# WIRE AND WIRE PRODUCTS

A monthly publication devoted to the production of Wire, Rod and Strip.
Wire Products and Insulated Wire and Cable.
DRAWING --- ROLLING--- EXTRUDING --- FORMING --- FABRICATING

Vol. 12 OCTOBER 1937 No. 10


# Abnormal Grain Growth And The Annealing of Low Carbon Steel Wire


By B. L. McCarthy,
Chief Metallurgist, Wickwire Spencer Steel Co., Buffalo, N. Y.

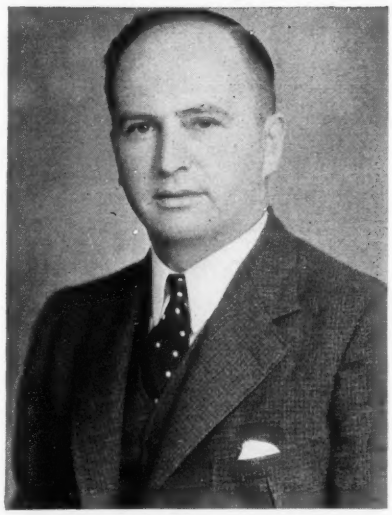


A study of the behavior of iron carbide in the annealing of low carbon steel wire together with an analysis of the changes that take place when low carbon steel is annealed at sub-critical temperatures.


✦ ✦ ✦ ✦

## Introduction

THE tendency for critically strained low carbon steel to develop abnormal grain growth on annealing was first established by **Stead** in 1898. Although it is confined to a limited range in carbon, and present only in steel which has been but lightly strained, nevertheless, it is often encountered in coarse sizes of annealed wire for such purposes as cold heading and forming operations. The enormous grain growth which results from a combination of critical strain and critical temperature produces an embrittling effect that greatly lowers the ductility of wire on bending or upsetting. To obtain a better understanding of this phenomenon, and the factors, in connection with the manufacture of steel wire, which influence it, an investigation was conducted by the author at the Buffalo plant of the Wickwire Spencer Steel Company. The data accumulated, and the many sidelights developed in connection with this study, seemed of sufficient value to present to you at this time. Of considerable interest to the author is the study of the behavior of the iron-carbide in the annealing of low carbon steel wire. It is hoped that the data and photomicrographs contained herein will not only add to the knowledge already available on grain growth, but also bring out more clearly the changes that take place when low carbon steel is annealed at sub-critical temperatures.



BENJAMIN LEWIS McCARTHY

Born in Lockport, New York, in 1895. In 1913 was employed as Assistant Chemist by Simonds Saw & Steel Co. In 1916 was employed by Wickwire Steel Co., now known as Wickwire Spencer Steel Co., as Assistant Chief Chemist. Three years later was promoted to Chief Chemist and Metallurgist. Now in charge of the Chemical and Metallurgical Laboratories and directs research and special investigation into the Chemistry and Metallurgy of steel, steel wire and wire products. Member of the Wire Association, The American Society for Testing Materials, and the American Society for Metals. Awarded the Wire Association Medal for the most meritorious paper on wire manufacture or fabrication during the year 1935.

✦ ✦ ✦

## Recrystallization of Low Carbon Steel After Cold Working

WHEN low carbon steel wire is cold worked, the grains, which are equiaxed in the hot-rolled or normalized condition, become elongated in the direction in which the metal flows. At the same time a degree of strain is set up in the metal which is directly proportionate to the amount of deformation taking place. On heating the metal after cold working, the distortion of the grains, and the strain, persist until a temperature of about 950°F is passed. Heating above 950°F results in a relief of strain, and at the same time a recrystallization occurs which produces new grains free from distortion. The new grains thus formed have the same general appearance of the grains that existed in the original metal prior to cold working.


**Designated as Official Publication by the Wire Association**

KRIVOBOK has detected the presence of an evolution of heat in cold worked low carbon steel at 1200°F. After the metal was heated above this temperature, no evolution of heat was detected on reheating. This indicates that cold working produces a definite reaction in the metal at 1200°F. which is not observed in the unworked material.

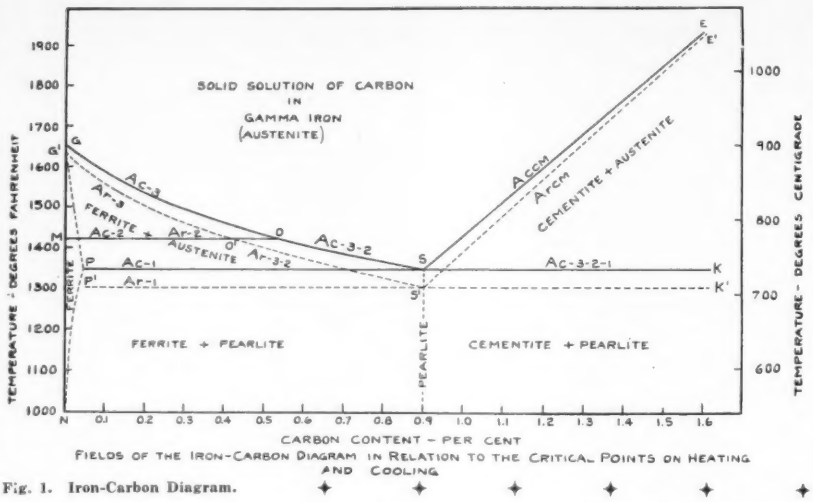


Fig. 1. Iron-Carbon Diagram.

✦ ✦ ✦

AS the temperature to which the steel is heated is raised above 950°F, the size of the new grains developed may be slightly larger than the original grains, but no appreciable grain growth is apparent. On heating to above 1340°F, the iron-carbide (cementite), which is present in low carbon steel in the form of pearlite, becomes dissolved in the surrounding ferrite and forms austenite. As the temperature to which the steel is heated is further increased, more and more of the ferrite is dissolved by the austenite, until, at a temperature of about 1600°F or thereabout, depending on the carbon content, all of the ferrite is dissolved and the steel is completely austenitic.

IN figure 1 is shown the iron-carbon diagram. The first solution of the iron-carbide in the ferrite to form austenite begins as the temperature passes the line PSK designated as the Ac-1. On further heating, solution of the ferrite in the austenite takes place along the line GS designated as Ac-3. At the point S, located on the line PSK, only the ferrite which is combined with the cementite to form pearlite is dissolved. As the temperature is raised, the solubility of ferrite in austenite is increased; this results in a lowering of the carbon content of the austenite. The point at which a line, drawn from a given carbon content at the bottom parallel to the line GN, intersects the line GS, represents the temperature at which complete solution of the ferrite takes place for a given carbon content.

ON cooling, the reverse takes place, and the ferrite (Iron) begins to separate out of the solid-solution of iron and carbon (austenite), separation taking place along the dotted line Ar-3 which, on slow cooling, is slightly below the line designated as Ac-3. This precipitation of the ferrite continues until the line Ar-1 is reached, at which temperature the iron-carbide precipitates out and the structure known as pearlite is formed. The grains which exist in the metal above the line GS are known as austenitic grains. The grains which are formed as the steel passes the line Ar-1 are termed the alpha grains or ferrite grains. The size of the ferrite grains developed after heating the steel to above the line GS and subsequently cooling, depends, to a large extent, on the rate of cooling and the length of time the steel was held at heat. In figure 2 is shown the ferrite grains developed in an .08 carbon steel on cooling in air from above the line GS. This sample was held at 1700° F for ten minutes. In figure 3 is shown the grain size of the same steel heated for twenty hours at the same temperature and furnace cooled.

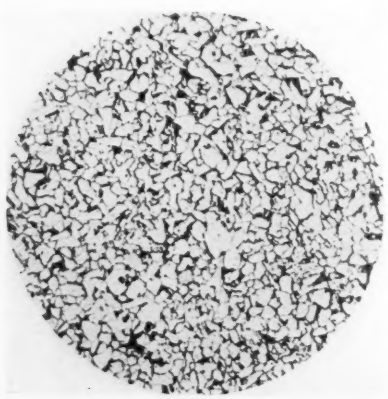


Fig. 2. .08 carbon steel cooled in air from 1625°F. —Average Grain diameter .000468". Magnification—200 X. ✦

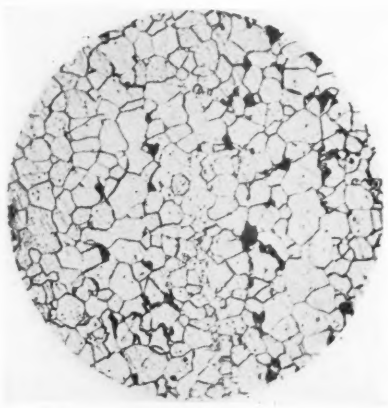


Fig. 3. Same as figure 2 holding for 20 hours at 1625°F. followed by slow cooling—Average Grain diameter .00072"—Magnification 200 X. ✦

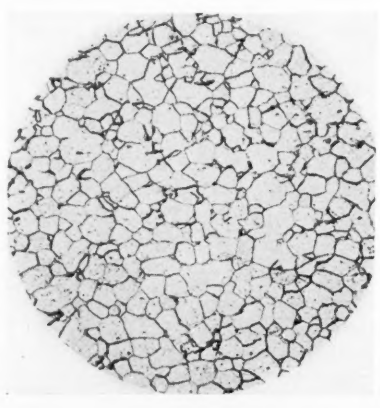


Fig. 4. Structure of .04 Carbon Steel slowly cooled from -1600°F. Magnification 200 X. ✦

THE dotted line GPN represents the solubility of cementite in ferrite. On cooling from above Ac-3, a portion of the iron carbide (up to about .05 carbon) is soluble in the ferrite. This results in a delayed precipitation which is not complete until the temperature is below 1000°F. As a result of this delayed precipitation, a portion of the iron-carbide is present in the steel in the form of fine spheroids, precipitation not having taken place until after the steel had cooled below the Ar-1, the point at which pearlite is formed. In figure 4 is shown the structure of a .04 carbon steel slowly cooled. Note the absence of the dark patches of pearlite. The small amount of carbon present in this sample resulted in the carbon all being present in the form of spheroids of Iron-Carbide instead of alternate plates of cementite and ferrite (pearlite).

✦ ✦ ✦

## Abnormal Grain Growth

THE above charges in the structure of low carbon steel represent what we may consider normal changes, and the grain sizes developed are those which take place under normal conditions. If, however, the amount of strain present in the metal falls within a narrow range known as the critical strain, the grains which result from the recrystallization of the cold worked metal may grow enormously. This abnormal growth is first noticed as the temperature of 1000° F is passed, and reaches its maximum at a temperature of about 1350°F. On heating to higher temperatures, the extent of growth is less, and the grain size of steels cooled from above the line GS will not be influenced by the amount of strain in the metal prior to heating. The amount of carbon present in the steel also influences grain growth. The maximum growth seems to be associated with the lower carbon material, the amount of growth diminishing as the carbon content is raised. In steels with a carbon content above .20 this phenomenon is not apparent.

WHILE it is true that the presence of a critical amount of strain is a requisite in producing grain growth in low carbon steels generally, as will be shown later, grain growth can be developed in the outer rim of rimmed steels which have not been strained. It is interesting to note that the center of the same steel which showed grain growth in the rimmed area on heating to 1350°F for 24 hours, did not show grain growth. (See figure 21). This indicates that the impurities in the metal have an influence on the growth of ferrite grain at sub-critical temperatures.

✦ ✦ ✦

NUMEROUS theories have been advanced to account for the recrystallization of cold worked metals at sub-critical temperatures. Most of these are based on germination, or the development of nuclei from which the grains grow, the number and occurrence of which influence growth. However, the present author feels that the solution of this phenomenon lies more in a better understanding of the atomic forces which are present in the metal at the time of heating, and that the recrystallization which takes place at sub-critical temperatures can be the result of forces of secondary valence combining with the strain set up as a result of cold work, to overcome the rigidity of the metal at these temperatures. The fact that a critical strain is required to produce grain growth, and that this strain occurs in steel within a limited range of carbon content only, leads one to believe that a critical amount of forces are set up which effect a maximum amount of grain growth. The presence of strains in excess of the critical amount, and the presence of too much carbon, might result in only the strains resulting from cold work being relieved, and a retention of the original grain boundaries, or, approximately the original grain boundaries without the forces of secondary valence, being effective. This is only hypothetical, but it does seem that the reason for the growth which develops as a result of a critical strain has to do more with the effect of these forces on the rigidity of the metal than on the formation of nuclei.

✦ ✦ ✦

THE manner in which the metal is strained, whether it be the result of dynamic or static stresses, in developing the critical amount of strain required to produce grain growth, does not seem to be important. **Chappell,** working with tapered tensile specimens, developed grain growth employing tensile stresses; **Sauveur** and **Charpy** employed the Brinell Ball impression to demonstrate it. Abnormal grain growth can be produced by bending the unworked low carbon steel following by annealing. (See figure 23). Here we develop strains resulting from stresses of tension and compression in the same specimen; both seem to exert the same influence.

✦ ✦ ✦

WE now have before us a phenomenon which involves a critical amount of strain, a narrow range of carbon, and which reaches its maximum at a critical temperature. This is known as **Stead's Brittleness or Abnormal Grain Growth.** First observed by Stead in 1898 [1]*, Abnormal Grain Growth has been the subject of extensive investigations by **Sauveur**[2], **Chappell**[3], **Goerens**[4], **Jeffries** and **Archer**[5], and others. The most complete description and examples of it are to be found in **Sauveur's** Treatise on "The Metallography and Heat Treatment of Iron and Steel"[6]. The tendency for critically strained metals, other than iron, to develop grain growth has been studied, and pieces of metal composed of a single crystal have been produced in this manner.

✦ ✦ ✦

## Grain Growth in Steel Wire

ADAMS[7] has referred to this phenomenon in connection with the manufacture of steel wire, and states that the range of drawing, in which grain growth develops in wire on annealing below the critical, lies between 8% and 12% reduction. **Sauveur**[6] refers to the fact that low carbon steel

* See reference.

wire, lightly drafted, will produce grain growth on heating to 1200° F. He also quotes **Lewis** as having established a minimum reduction of 20% in drawing to avoid grain growth in steel wire.

✦ ✦ ✦

IN order to clarify the influence of strain resulting from wire drawing, the temperature range in which Grain Growth occurs, and the effect of analysis of both the rimmed and killed low carbon steels on this phenomenon, the experiment outlined below was conducted.

✦ ✦ ✦

## Outline of Experiment

FOUR different steels, two rimmed and two killed of varying carbon content were employed. The chemical analyses of these steels are shown in Table I.

✦ ✦ ✦

STEELS A and B were made by the rimming process. Steels C and D were killed by the addition of Ferro-Silicon to the ladle.

✦ ✦ ✦

THE four steels listed above were hot rolled to #4 rod, cleaned, limed, baked, and drawn one draft to .177. At this point they were run through the patenting furnace at a temperature of 1800°F. This removed all the strains set up in drawing, and produced a normalized wire of uniform diameter. The normalized samples were again cleaned, limed and baked, and a number of pieces from each steel were prepared as follows: A die was selected which would reduce the cross sectional area of the wire 40%, (previous tests having shown that this amount of reduction would develop a strain in excess of the critical amount which produced grain growth), and the .177 wire pointed and started through the die. Shortly after the block was started, it was stopped, and the wire backed out of the die. This produced a section which contained some of the original normalized wire, a tapered section with reductions varying from 0 to 40%, and a small section of wire drawn 40%. One sample of each of the four steels shown above prepared in this manner was packed in a small carburizing box, surrounded by steel drillings to avoid decarburization, and heated for 24 hours to the following temperatures, 700, 800, 900, 1000, 1100, 1200, 1300, 1350, 1400, 1500, 1600, 1700 degrees fahrenheit. 1350°F. was included because it became apparent that the maximum growth developed at or near this temperature. The time of 24 hours was selected to establish equilibrium as regards grain growth and to bring out the maximum influence.*

TABLE I

| Steel | Carbon | Manganese | Sulphur | Phosphorus | Silicon |
|---|---|---|---|---|---|
| A | .05 | .25 | .039 | .014 | Nil |
| B | .10 | .40 | .042 | .036 | Nil |
| C | .10 | .36 | .038 | .012 | .17 |
| D | .15 | .38 | .040 | .018 | .24 |

✦ ✦ ✦

ALL the samples treated were then carefully prepared for micro-examination by sectioning longitudinally at the axis and setting them in suitable holders. In figure 5 is shown the type of section employed. By the use of the microscope fairly accurate measurement of the percent reduction could be obtained, and the change in structures resulting from cold working and heating could be studied.

✦ ✦ ✦

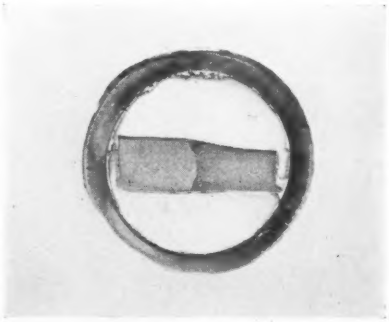


Fig. 5. Type of Specimen employed. Magnification 2-X.

✦ ✦ ✦ ✦

## Normal Grain Size

THE term "normal grain size", as employed herein, is intended to indicate the normal condition, whether the sample has been cooled slowly, as in the furnace, or whether it was cooled in air, as against the abnormal growth resulting from critical strain.

✦ ✦ ✦

IN determining the size of the grains, in connection with this work, the author has employed the intercept method of counting and measuring the grains suggested by **Jeffries and Archer**; the measurements shown represent the average grain diameter. It should be borne in mind that the figures shown are of value only for the purpose of comparison and while they serve to convey some impression of the size of the grains in low carbon steel, they are by no means intended as standard measurements. In figures 6, 7, 8 and 9 are shown photomicrographs of the four steels in the normalized condition. That the amount of impurities present has an influence on the grain size developed is shown by the fact that the average grain diameter decreases as the carbon content increases. The rimmed steels A and B were photographed at the center. Note the non-uniformity of grain size in figure 7. This is due to a banded condition in the steel resulting from segregation of impurities.

✦ ✦ ✦

TO demonstrate the influence of cold working on the normal size of the grains formed on annealing, the data given in Table I was obtained.

✦ ✦ ✦

THESE figures show the difference in grain size between the rimmed steels and the killed steels,

**Note:—We regret that studies on the amount of time required to develop grain growth could not be included in this paper; work along this line has been started, but time will be required for its completion.**

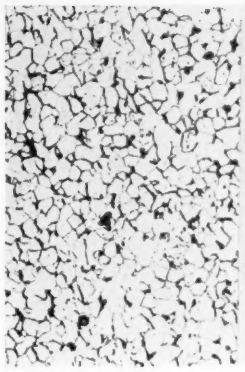


Fig. 6. Sample A. Average Grain Diameter .000577.

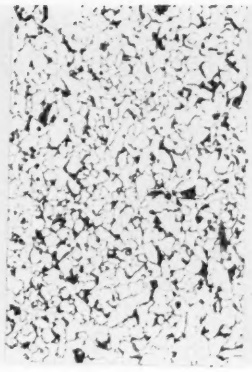


Fig. 7. Sample B. Average Grain Diameter .000441.

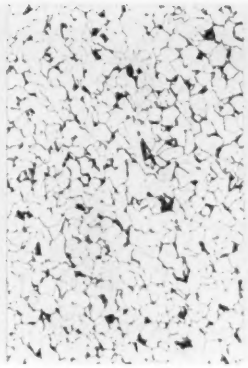


Fig. 8. Sample C. Average Grain Diameter .000394.

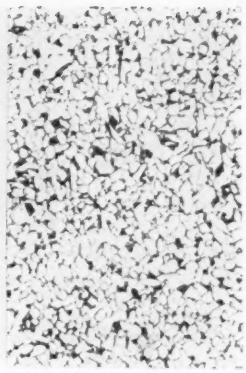


Fig. 9. Sample D. Average Grain Diameter .000326.

Normalized Structure of Steels Employed—Magnification 200 X

✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

TABLE I

AVERAGE GRAIN DIAMETER AFTER HEATING FOR 24 HOURS TO THE TEMPERATURES SHOWN BELOW, FOLLOWING BY SLOW COOLING

| | A | | B | | C | | D | |
|---|---|---|---|---|---|---|---|---|
| Steel | b | a | b | a | b | a | b | a |
| Normalized | .000577 | | .000441 | | .000394 | | .000326 | .00041 |
| After Heating to | | | | | | | | |
| 1100 | .00050 | .00054 | .00041 | .00043 | .00036 | .00039 | .00035 | .00047 |
| 1300 | .00057 | .00061 | .00045 | .00056 | .00041 | .00054 | .00038 | .00052 |
| 1400 | .00062 | .00069 | .00051 | .00064 | .00044 | .00061 | .00040 | .00057 |
| 1500 | .00070 | .00076 | .00062 | .00073 | .00056 | .00070 | .00052 | .00065 |
| 1600 | .0008 | .00102 | .00074 | .00092 | .00072 | .00081 | .00068 | .00079 |

b—Before cold working. a—After colding working 40%.

and between the two different analyses made by each process. In every instance the recrystallization resulting from cold work has resulted in a larger grain size.

✦ ✦ ✦

UNDER normal conditions, the grains of ferrite found in the rimmed area of rimmed steels are coarser than those found in the center, the effect of added impurities in the center obstructing grain growth. In figure 10 is shown a photomicrograph taken at a point where the rim and center meet on sample A. Note the larger grains at the top, which was a portion of the rim, as compared with those at the bottom, a portion of the center. Note the comparatively sharp change in grain size between the rim and center. In this work, unless otherwise stated, only the center of the rimmed samples was considered in the data obtained, the behavior of the rim being such as to exclude it.

TO demonstrate the effect of 40% reduction in drawing on the various steels, the photomicrographs shown in figures 11, 12, 13 and 14 were prepared.

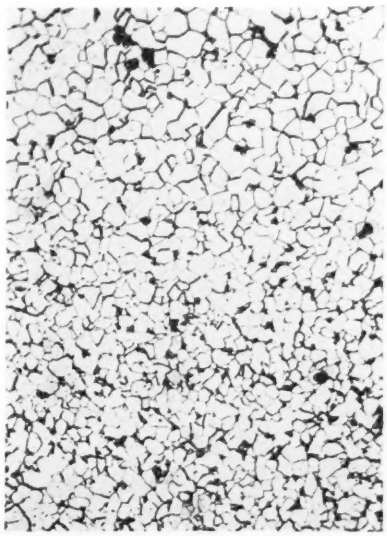


Fig. 10. Taken at Point between Rim and Center of Sample A. Average Grain Size—
At top .0006
At Bottom .00046
Magnification 200 X. ✦ ✦ ✦

IN figure 15 an area taken from sample B at the point of 8% reduction is shown. The amount of strain, or grain distortion, apparent in this sample should be carefully noted, for, as will be shown later, this is approximately the area which contains the critical amount of strain and which produces the maximum grain growth.

✦ ✦ ✦

IN figures 16, 17, 18 and 19 are shown photomicrographs taken at the point of maximum grain growth. The temperature to which these samples were heated was 1350°F. As demonstrated by **Sauveur**, the maximum grain growth develops at a point adjacent to the understrain. To illustrate this, a small portion of the understrained area is included. Note the wide difference in grain size developed. This will show the extent to which the grains of low carbon steel can grow as the critical amount of strain is employed. While, as shown above, the maximum grain

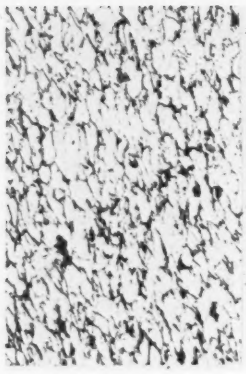


Fig. 11. Sample A.

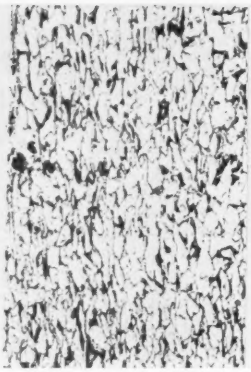


Fig. 12. Sample B.

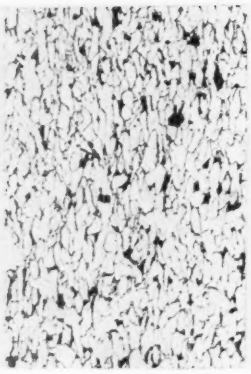


Fig. 13. Sample C.

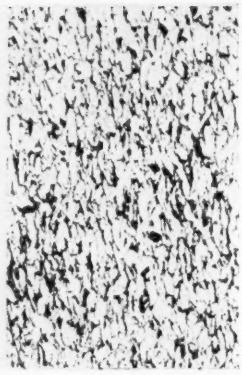


Fig. 14. Sample D.

Showing the Distortion of the Grains as a Result of Cold Working Samples A, B, C, and D, 40%. Magnification 200 X.

✦ ✦ ✦

growth develops at a point adjacent to the understrained metal, it does not terminate abruptly as the overstrained metal is approached.

✦ ✦ ✦

INSTEAD, there is a gradual diminishing of the grain size, from the point of maximum growth to the point of overstrain, which produces no grain growth. This is shown in figures 16, 17, 18 and 19. This proves that grain growth in varying degrees can develop over a range of reduction in drawing. It was found that the maximum grain growth occurred at a point between 6% and 7% reduction, the 6% value being obtained on steel A after heating to 1350°F, the killed steels seemed to develop the critical strain at a slightly higher percent reduction, in the neighborhood of 7%.

✦ ✦ ✦

AS will be shown later, grain growth in the rim of rimmed steels was developed without any strain being present, thus making a study of the influence of strain on the rim of no value. Undoubtedly a much lower strain than that produced by 6% reduction would cause grain growth in the rim, and evidence to this effect was developed. However, due to the erratic nature of this growth, nothing of value could be established. The maximum range of reduction over which some grain growth was apparent was found to be from 6 to 16%. This was in steel A heated to 1350°F. Steel B had a range of from 6½ to 15%, Steel C 6½ to 14%, while the maximum range for D was from 7 to 11%. These figures were all taken from the samples heated to 1350° F, this temperature being the maximum for all four steels. As the temperature to which the samples were heated was raised or lowered above or below 1350°F, the range in percent reduction over which grain growth was evident was lessened. Some conception of how the range over which grain growth occurs decreased, as the carbon content was increased, can be obtained from an examination of the photomicrographs shown in figures 16, 17, 18 and 19.

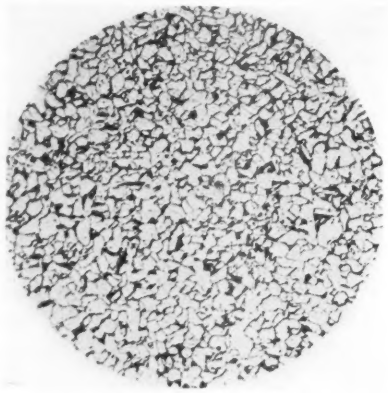


Fig. 15. Sample B taken at 8% Reduction in Drawing. Magnification 200 X. ✦ ✦

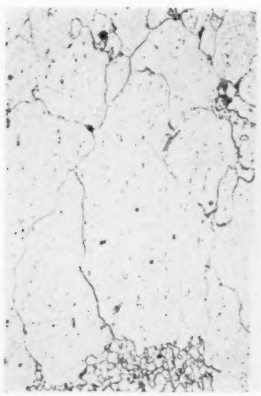


Fig. 16. Sample A. Average Grain Dia. .013″.

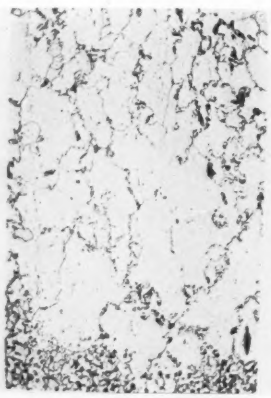


Fig. 17. Sample B. Average Grain Dia. .005″.

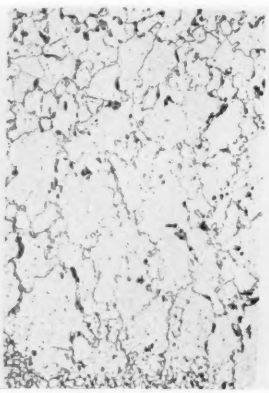


Fig. 18. Sample C. Average Grain Dia. .00375″.

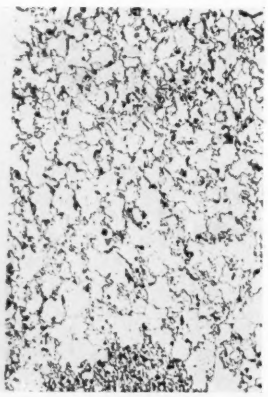


Fig. 19. Sample D. Average Grain Dia. .0017″.

After Heating for 24 Hours at 1350°F.—Showing Areas of Maximum Grain Growth. Note how largest grains occur adjacent to understrained areas (at bottom). Magnification 100 X. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

THE range in temperature over which grain growth occurred was also observed, and it was found that the four steels varied in this respect also. Steel A began to coarsen slightly at 1000°F, and coarsening was apparent until the steel had been heated to 1700°F. Steel B started to coarsen at 1100° F, but no coarsening was observed at 1600°F. Steels C and D both coarsened at 1200°F, no coarse grains being apparent after heating to 1500°F. This indicates that the analyses influences the range of temperature over which grain growth will occur, and that the addition of carbon raises the temperature at which it begins, and lowers the temperature at which it ends. It is interesting to note, however, that 1350°F seems to be the temperature at which maximum grain growth for all four steels is reached.

✦ ✦ ✦

WHEN one considers this in connection with the iron carbon diagram (figure 1), the reason becomes apparent. As the carbon content increases, more austenite is formed as the temperature exceeds 1350°F, which on cooling produces a normal ferrite grain size. In steel containing .10 carbon and over, such as B, C and D, the line GS will be passed before the temperature of 1600°F is reached, this will result in the development of austenite, and the crystallization which takes place in cooling will produce normal ferrite grains. The coarse grains found in Steel A after heating to 1600°F were those which were not dissolved because the temperature was not high enough. The extent to which the grains coarsened varied in the four steels; above, center is shown the average grain diameters for the four steels taken at their maximum after heating to 1350°F.

✦ ✦ ✦

TO confirm our finding as regards grain growth, a portion of sample A was drawn to 10% reduction, and heated for 24 hours at a temperature of 1350°F. In figure 20 is shown the structure developed. This structure persist-

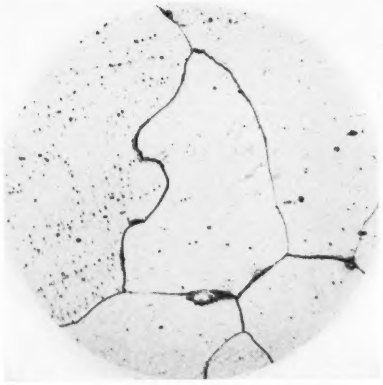


Fig. 20. Sample A Drawn 10% followed by Heating for 24 hours at 1350°F—Average Grain Diameter in this sample was .015. Magnification 200 X.

✦ ✦ ✦ ✦

ed throughout the entire cross section of the sample. It shows a larger grain size than that found in sample A (figure 16) wherein the critical strained area was less. The fact that the whole wire was critically strained produced more freedom of growth, and a larger grain size resulted.

| Steel | A | B | C | D |
|---|---|---|---|---|
| Average Grain Diameter | .013 | .005 | .00375 | .0017 |

WHILE this study has confirmed the finding of **Lewis** regarding the need of a reduction of more than 20% to insure the absence of grain growth on annealing, the author feels that the minimum reduction for low carbon steel wire to be subsequently annealed should be higher than this figure. If we are dealing with a perfectly round wire, 20% would be sufficient. However, when the hot rolled rod is being drawn, it is possible to have in the same cross section strain gradients which result from a variation in the amount of working the rods may receive because of variations in the diameter. Also, when we consider the possibility of strain gradients due to segregation, to avoid the possibility of a local growth in a certain area, and to insure the absence of such growth, it is recommended that 30% reduction be employed as the minimum instead of 20%.

Fig. 21. Showing rim and center of Sample A after heating to 1700°F., Air Cooling then heating to 1350°F. for 24 hours. Magnification 50 X.

✦ ✦ ✦

## Grain Growth in the Absence of Strain

IN the course of this study, it was observed that, in some instances, the rim of the rimmed steel samples A and B coarsened in the area which had received no cold work. To establish this definitely, a sample of steel A was heated to 1700°F to remove all traces of strain resulting from cold work, and cooled in air. It was then heated to 1350°F for 24 hours. As a result, the grains in the rimmed area grew enormously. This accounts for the grain growth often observed in the rim of annealed low carbon wire made by the rimming process. No abnormal growth was observed in the center. In figure 21 a photomicrograph of this sample shows a portion of the rim and center; note the difference in grain size.

✦ ✦ ✦

## Behavior of Electrolytic Iron

TO determine whether the greater purity of the rim in itself accounted for the growth that occurred, a sample of Electrolytic iron of the analysis shown at the top center of following page, was subjected to the same treatment.

✦ ✦ ✦

IN figure 22 is shown the structure developed after this treatment. It is obvious that the growth associated with the rimmed area noted above results not from the degree of purity alone but from some influence which is not clearly understood.

TO determine whether the laws which govern abnormal grain growth would apply to iron in a purer state than found in steel, the sample of electrolytic iron referred to above was strained by bending on itself and then being heated for 24 hours at a temperature of 1350° F. It was found that grain growth developed, and, due to the strain gradients present in the sample as a result of bending, a most interesting sample was produced. This sample is shown in figure 23 (taken at 50 X). A careful examination will show that we have **both** the growth resulting from compression on the inner portion, and that associated with tension on the outer side. Also, that at a point approximately in the center, where a minimum of strain was set up, fine grains were present.

✦ ✦ ✦

THE fact that the largest grains develop near the understrained area is again obvious; that the overstrained areas, at the inner and outer surfaces of the bent specimen showed a tendency towards finer grains, checks with some of our previous findings outlined above. This sample gives a clear picture of how strain gradients can produce a variation in grain growth. It also indicates that the elements Manganese, Sulphur, Phosphorus, and Silicon, do not promote grain growth, and that grain growth can develop in extremely low carbon iron as well as in steel.

✦ ✦ ✦

## Influence of Segregation

IN figure 24 is shown an interesting structure developed during this work. It is obvious from this, that, due to a segregation in the steel, a small area had not received its full quota of cold work. This probably was due from a resistance to deformation in this area as a result of segregation. A higher reduction in drawing was required to effect grain growth in this area.

✦ ✦ ✦

## Lag in Transfer of Stress

ANOTHER interesting observation, made in connection with this study, was that almost every sample, in which grain growth occurred, showed the critical strain point to be a curve. An example of this is shown in figure 5. This indicates that the critical amount of strain required to produce grain growth was reached at the edge before the center. It indicates that there is a lag in the transfer of stress from the outside to the center, and that more strain is present at the surface than in the center. It also shows, however, that this delay in the transfer of stress is very slight. I know of no other way of determining the slight difference in stress penetration that may be present in a piece of steel wire.

ELECTROLYTIC IRON

| Carbon | Manganese | Sulphur | Phosphorus | Silicon |
|---|---|---|---|---|
| .03 | .00 | .010 | .005 | .01 |

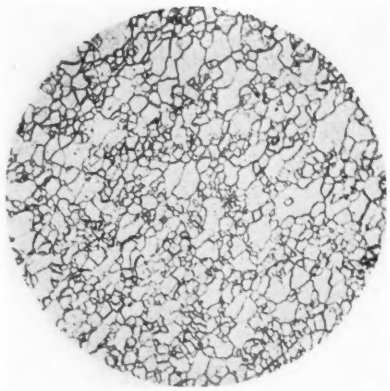


Fig. 22. Sample of Electrolytic Iron treated the same as sample shown in Fig. 21. Note the absence of Grain Growth. Magnification 200 X.

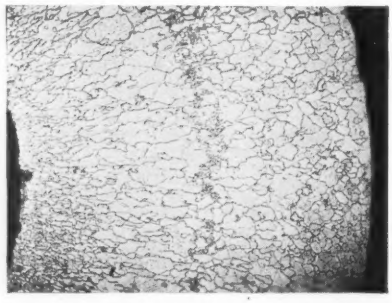


Fig. 23. Sample of Electrolytic Iron showing the grain size developed on heating a bent portion for 24 hours at 1350°F. Magnification 50 X. ✦

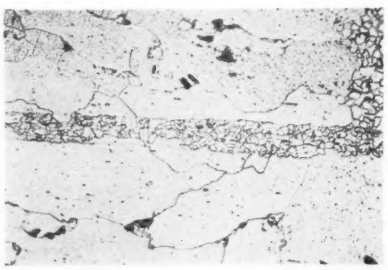


Fig. 24. Structure found in Steel A after heating critically strained area to 1350°F. for 24 hours. Segregation has resulted in strain gradients and a variation in grain growth has resulted. Magnification 100 X. ✦ ✦ ✦

## Behavior of Pearlite on Annealing

THE non-uniformity often found in pot-annealed low-carbon steel wire is familiar to all of us. The reason for this non-uniformity is due, primarily, to our inability to heat the material to a uniform temperature throughout, and for a uniform period of time. Too often, in order to save time, the furnace atmosphere, which surrounds the pot, is maintained at too high a temperature. As a result, the portion of the wire on the outside of the stem will be heated to a much higher temperature than that in the center. Even if the temperature of the furnace is not too high, there is still a lag in the heat penetration, resulting in a different treatment of the outside than the center. Quite often, due to the manner in which the furnace is heated, there is a marked difference between the wire on the top and that on the bottom. These variations whether they be in time at heat or in temperature, produce variations in the microstructure. These variations can be detected, to a certain extent by a microscopic study of the condition in which the iron-carbide is found in the wire.

✦ ✦ ✦

IN the hot rolled rod, the iron-carbide is found in plates associated with ferrite, to form the structure pearlite. On heating to 1100°F, there is a tendency for this plate-like structure to break-down, and the cementite to coalesce into rounded particles or spheroids. The extent to which this spheroidization develops depends on the tem-

perature to which the material is heated, and the time at heat. If, due to excessive heat in the furnace surrounding the pot, the steel is heated above 1400°F, the structure of pearlite will again be in evidence. The reason for this is shown by a study of the iron-carbon diagram in figure 1. As shown above, when the temperature exceeds 1340°F (line PSK), the iron carbide and ferrite dissolve to form austenite, and on subsequent cooling pearlite will be formed. Because of non-uniform heating, it is not uncommon to find the iron-carbide both in the spheroidized condition and in the form of pearlite in the same coil of wire.

✦ ✦ ✦

TO obtain a clearer understanding of the behavior of the iron-carbide, when low carbon steel wire is annealed at various temperatures, the author has made use of the heat treatments employed in the work shown above. The influence of cold working on the changes in the iron-carbide particles is also worthy of consideration, and the behavior of both the unworked steels and the steels drawn to 40% reduction have been studied. Steel D only was used to demonstrate these changes, because the increased amount of carbon present in this sample made the behavior of the iron-carbide easier to observe.

✦ ✦ ✦

IN figures 25, 26, 27, 28, 29 and 30 are shown the structures developed in Steel D after heating to 1100, 1200, 1300, 1400, 1500 and 1600 degrees fahrenheit for 24 hours. These photomicrographs were taken in the area which had not been cold worked. The portions which had been cold worked to 40% reduction and then heated in the same manner are shown in figures 31, 32, 33, 34, 35 and 36. A magnification of 1000 diameters was employed in this study to enable us to see more easily the changes that take place.

✦ ✦ ✦

A CAREFUL examination of these photomicrographs will show a tendency towards spheroidization in figure 25 which is more developed as the temperature is raised; also, that in the cold worked metal, spheroidization proceeds more rapidly (compare figures 25 and 31). This spheroidization continued until the temperature of 1350°F (line PSK, figure 1) was passed, after which point the structure of pearlite began to appear. The pearlite formed after the treatment at 1400°F is coarse and shows a tendency towards coalescence of the cementite: as higher temperatures are employed, however, a more well developed pearlite is formed.

✦ ✦ ✦

YOUR attention is called to the manner in which the spheroids appear in striations in the cold worked specimens as compared with the absence of this in the unworked material. This striation is evidence that the only change that takes place in the pearlitic areas on heating below 1350°F is the relief of strain and spheroidization of the cementite, recrystallization of the pearlite not taking place until the solid solution (existing above the line GS, figure 1) is developed.

✦ ✦ ✦

THE tendency for the ferrite grain size of the cold worked metal to be larger than that of the

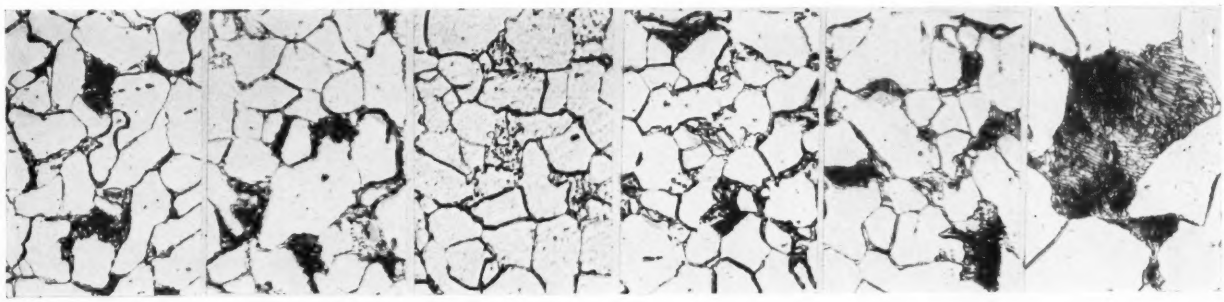


Fig. 25. 1100°F. Fig. 26. 1200°F. Fig. 27. 1300° F. Fig. 28. 1400°F. Fig. 29. 1500°F. Fig. 30. 1600°F.
Showing the Condition of the Cementite Developed as a Result of Heating Unworked Samples of Steel D for 24 Hours at the Above Temperature. ✦

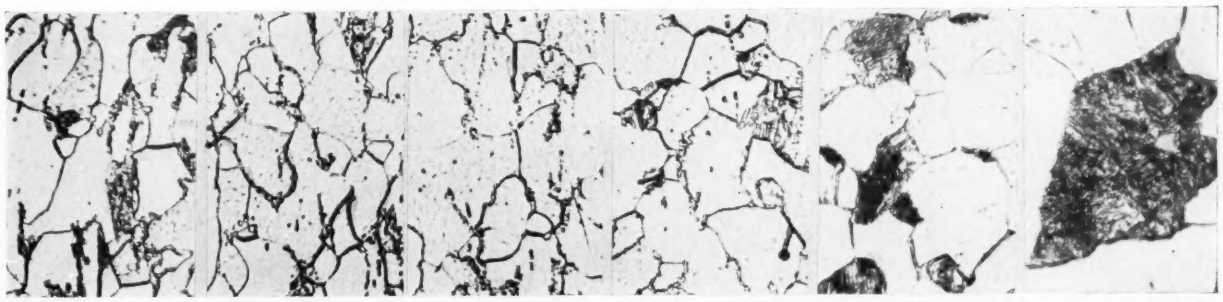


Fig. 31. 1100°F. Fig. 32. 1200°F. Fig. 33. 1300°F. Fig. 34. 1400°F. Fig. 35. 1500°F. Fig. 36. 1600°F.
Showing the Condition of the Cementite Developed as a Result of Heating Samples of Seel D., Cold Worked 40% for 24 Hours to the Above Temperatures. All Taken at 1000 X. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

unworked metal is again obvious in these photomicrographs.

✦ ✦ ✦

A CAREFUL study of the structures shown in figures 25 to 36 inclusive will enable the wire mill metallurgist to estimate the heat influence on the annealed wire. It is difficult to determine by means of pyrometers the exact heat influence imparted to wire on annealing in pots. By a study of the microstructure, however, the condition of the wire which resulted from the annealing can be determined.

✦ ✦ ✦

WHEN a shorter time than 24 hours at heat is employed, the degree of spheroidization shown above will be less. If, however, the steel goes above 1400°F, the structure of pearlite will appear.

✦ ✦ ✦

## Summary

LOW carbon steel wire cold worked between 6 and 16% reduction is apt to develop grain growth on annealing.

✦ ✦ ✦

THE critical strain point which produces the maximum growth is in the neighborhood of 7%. The maximum growth develops at a critical amount of strain which lies close to the understrained area, but grain growth can be present in varying degrees over a range in strain resulting from wire drawing.

✦ ✦ ✦

THE range in temperature over which grain growth can occur, may be from 1000°F to 1600°F, depending on the analysis of the steel and the degree of strain, the range of strain which produces grain growth being small at 1000° F, reaching a maximum at 1350°F and falling off again as the temperature is increased.

✦ ✦ ✦

AN increase in the carbon content of the steel results in a narrowing down of the range in temperature which will produce grain growth and also the range of percent reduction over which grain growth occurs. When the carbon content is in excess of .20 percent, no grain growth resulting from strain is apparent.

✦ ✦ ✦

THE temperature of 1350°F is the critical temperature at which maximum grain growth will develop as a result of critical strain regardless of the carbon content.

✦ ✦ ✦

A MINIMUM reduction of 30% in drawing for low carbon steel wire, which is subsequently annealed, is recommended to avoid the possibility of grain growth.

✦ ✦ ✦

GRAIN growth can occur in the rim of rimmed steels in the absence of strain at a temperature of 1350°F. The reason for this is not quite apparent. That it is not due to the degree of purity alone is demonstrated by the fact that Electrolytic Iron which is much more pure, does not grow on heating to the same temperature.

✦ ✦ ✦

GRAIN growth can develop in Electrolytic Iron if the amount of strain present falls in the range of critical strain. It does not occur, however, if the strain is greater or less than the critical amount of strain.

✦ ✦ ✦

STRAIN variations between the center of a piece of wire and the outside do exist to a minor degree, the outside being more highly strained than the center. This seems to be due to the inability of the metal to transfer the stress of cold working quickly. It indicates that a lower speed of drawing will result in a more uniform strain condition in the wire.

✦ ✦ ✦

THE condition of the Iron-Carbide as found on examination under the microscope may be employed to indicate the influence of heat on the metal as a result of annealing, the degree of spheroidization and the presence of pearlite being the index.

COLD work present in low carbon steel wire will accelerate the spheroidization of the cementite.

✦ ✦ ✦

## Reference


(1)—STEAD:—
"BRITTLENESS PRODUCED IN SOFT STEEL BY ANNEALING"
Journal of Iron and Steel Institute No. II PP 137-184, 1898.

(2)—SAUVEUR:—
"NOTES ON THE CRYSTALLINE GROWTH OF FERRITE BELOW ITS THERMAL CRITICAL RANGE"
Proceedings International Association of Testing Materials—1912—Vol. II.

(3)—CHAPPELL:—
"RECRYSTALLIZATION OF DEFORMED IRON"
Journal of Iron and Steel Institute 1-1914.

(4)—GOERENS:—
ON THE INFLUENCE OF COLD WORK AND ANNEALING ON THE PROPERTIES OF IRON AND STEEL"
Iron and Steel Institute Carnegie Scholarship Memoirs—Vol. III—1911.

(5)—JEFFRIES AND ARCHER:—
"THE SCIENCE OF METALS"
McGraw Hill Book Company PP-108-110.
370 Seventh Street, New York, N. Y.

(6)—SAUVEUR:—
"THE METALLOGRAPHY AND HEAT TREATMENT OF IRON AND STEEL"
McGraw Hill Book Company
370 Seventh Street, New York, N. Y.

(7)—ADAMS:—
"WIRE DRAWING AND THE COLD WORKING OF STEEL"
H. F. & G. Witherby
326 High Holborn, London, England.



The writer wishes to express his appreciation to the management of the Wickwire Spencer Steel Company for permission to publish the results of the studies shown herein.

# A Metallurgical Study of The Factors Affecting The Quality of Galvanizing

By R. W. Sandelin
Metallurgist, Atlantic Steel Co., Atlanta, Ga.

**A study of galvanizing defects as affected by the nature of the steel base, referring particularly to the gray spotting which occurs on sheet and strip. The work represents independent research carried out in connection with a professional engineering degree.** ✦ ✦ ✦

THE practice of coating steel articles with zinc as a means of protecting the base metal is very widespread and holds an important place in industry. Zinc coatings may be applied electrochemically is in the case of electroplated bolts, nuts, washers, wire and other products; or the coating may be applied by means of a hot-dipping process, in which case the articles are immersed in a bath of molten zinc. Zinc coatings applied by means of the hot-dipping process are subject to the influence of a number of factors each of which has an effect on the quality and surface appearance of the coating. Surface appearance is a factor of utmost importance since it is the basis for the judgment of the relative quality of a galvanized coating by the trade.

✦ ✦ ✦

THE appearance of hot-dip zinc coatings on strip and sheets is characterized by the presence of a spangle, and any factor or factors which would cause the elimination or its non-uniformity would thereby be a cause for the rejection of such articles, since generally speaking, they are not acceptable to the trade.

✦ ✦ ✦

FREQUENTLY sheets and strip after galvanizing have a dull gray appearance, sometimes in certain portions only, and at other times over the entire surface. Such gray "spots" are sufficient cause for the rejection of the article by inspectors in the mill as well as by the trade. Therefore, the elimination of such defects and a study of their origin is of great importance to this branch of industry.

✦ ✦ ✦

THE present study is an effort to determine the cause and mechanism of such spot formation, and includes in general, the study of such factors as the effect of manipulation during the actual galvanizing process, and the effect of the type of steel as manufactured in the Basic Open Hearth Furnace.

✦ ✦ ✦

OTHER investigators have published data arriving at conclusions, in some cases contradictory, and in any case not pointing directly to the ultimate causes, which in the present paper are found to be a combination of proper operating procedures in the galvanizing plant together with the use of the correct type of steel. **Hannah** and **Rhead** (1)[1] concluded that impurities in the zinc bath were the primary cause of such defects and that the nature of the steel base had little or no effect. Their conclusions, arrived at as a result of laboratory experiments, are unwarranted in view of data obtained by other investigators, (2), (3). **Poppleton** (4) concluded as a result of mill practice that overpickling is a cause for non-spangled gray sheets. **White** (5) has shown that the quality of the steel base plays an important part in the occurrence of spots. He noted that gray sheets stripped of their gray-zinc coating and regalvanized persisted in turning gray whereas other sheets galvanized at the same time under identical conditions did not turn gray but had bright spangled surfaces instead. **White** also noticed that certain areas on a sheet would turn gray and that other portions spangled in a proper manner. **White** concluded that the retention of hydrogen by the iron during pickling operations was the cause of gray sheets. He further noted that the

R. W. SANDELIN

Graduated from the University of Minnesota 1931; instructor in Metallurgy at the Georgia School of Technology 1931-1934; Metallurgist for the Atlantic Steel Company, Atlanta, Georgia, 1934 to date. Member of The Wire Association.

1.—The figures appearing in parentheses refer to the bibliography appended to this paper.

alloy layer, after stripping off the top layer, had numerous elevations of blisters which were supposedly caused by the evolution of hydrogen during the galvanizing process; the roughened surface therefore providing numerous neuclei forming an indistinct spangle.

✦ ✦ ✦

OTHER investigators, **Rosenberg** (6) and **Singmaster** (7) have concluded that the spangle is no indication of quality and that some users demand a sheet "free from spangle" for high grade products. Such users however are an exception to the general class of buyers and consumers of galvanized products. **M. von Schwarz** and **H. Fromm** (8) in their recent work concluded that the more completely the carbon was precipitated in low carburized sheets during annealing as grain boundary cementite the more uniform was the galvanizing, and the galvanizing was inferior where pearlite occurred along with the grain boundary cementite. This was attributed to the action of the hydrogen which penetrates during pickling into any discontinuities in the grain structure and is driven out again by the heat of the galvanizing bath and thus disturbs the crystallization of zinc.

✦ ✦ ✦

DUE to the increasing emphasis and importance placed upon the general outward appearance of present day products whether they be galvanized or not, it is highly important to satisfy the ultimate consumer who, in many cases, is guided in his judgment by appearances alone.

✦ ✦ ✦

THE present paper is divided into two main parts, the first being devoted to the study of the mechanism of spot formation as determined by the physical characteristics of the coatings and effect of various operating procedures, and the second part which is mainly concerned with occurrence of spots as related to a particular type of steel.

✦ ✦ ✦

## Materials

TWENTY steels were used in the present investigation; the analyses are given in Table I. The steels are all of commercial grade and of the semi-killed type. As received, they were in the form of billets 1¾ inches square. Samples for metallographic study were cut from these billets, the remainder of which was then rolled into strip, band or angles for galvanizing test purposes.

✦ ✦ ✦

## Mechanism of Spot Formation

THE first observations of spot formation were made on galvanized strip which was galvanized continuously by riveting together the ends of the coils and passing them through long shallow pickling tanks to remove scale, then into the flux tank and finally into the spelter pan. The galvanized strip was coiled on motor driven reels at the opposite end of the line of operations. It was noted that spots occurred at various intervals and that at such times caused a great deal of concern since much of the product was rejected and had to be re-galvanized. At that particular time the degree of control that could be exercised by the operator was slight, the result being that when spots occurred, very little could be done about it. It was finally concluded that the particular heat of steel was an important factor together with other factors of a variable nature. That the steel played an important part in this particular type of defect was quite evident since other heats of steel of similar analysis and galvanized under identical conditions did not spot at all or in other cases to a lesser degree. It was also noted in these early observations that room temperature had an effect on spotting and that in cool weather spotting was less pronounced.

✦ ✦ ✦

A STUDY of the effect of various operating conditions was made at a time when the flexibility of operations of the galvanizing unit had been improved; these are listed below.

✦ ✦ ✦

## Effect of Manipulation During the Galvanizing Process

### Effect of Temperature

SPOTTING is more pronounced at higher temperatures and while dependent upon the nature of the steel, size of the strip and the speed of the strip through the spelter, it is generally observed at temperatures above 830-840 degrees F. Therefore one means of eliminating spots is lowering of temperature.

TABLE I

Chemical Composition of Steels Used

| Steel No. | Percent Carbon | Phosphorus | Sulphur | Manganese |
|---|---|---|---|---|
| 1 | .31 | .058 | .040 | .64 |
| 2 | .30 | .058 | .040 | .60 |
| 3 | .29 | .088 | .050 | .45 |
| 4 | .34 | .065 | .024 | .42 |
| 5 | .29 | .050 | .024 | .42 |
| 6 | .32 | .064 | .025 | .52 |
| 7 | .32 | .066 | .025 | .49 |
| 8 | .32 | .065 | .047 | .46 |
| 9 | .32 | .087 | .032 | .57 |
| 10 | .32 | .064 | .030 | .51 |
| 11 | .32 | .072 | .028 | .55 |
| 12 | .33 | .027 | .036 | .49 |
| 13 | .31 | .012 | .035 | .45 |
| 14 | .22 | .021 | .029 | .41 |
| 15 | .20 | .027 | .037 | .50 |
| 16 | .18 | .020 | .029 | .46 |
| 17 | .16 | .016 | .035 | .46 |
| 18 | .33 | .073 | .029 | .58 |
| 19 | .16 | .009 | .027 | .31 |
| 20 | .22 | .035 | .033 | .55 |

## Effect of Immersion Time

SPOTTING is more pronounced at the shorter immersion time. Excessively long times however will produce a dull rough coating but is not a true spotting defect since metallographic investigation reveals the existence of a pure zinc layer which is not true in the case of a spot. Immersion times of less than 20-25 seconds will show maximum spotting effects. Time in the spelter is ordinarily governed by two factors, namely length of travel in the molten zinc and the rate of speed through the spelter pan. The time factor is best arrived at by regulating the position at which the strip enters the spelter since high speeds are desirable from the standpoint of tonnage and the elimination of spots, the latter being due to retarded drainage of zinc from the strip. The ideal condition permits maximum speed with just enough travel through the spelter to acquire a coating of satisfactory thickness.

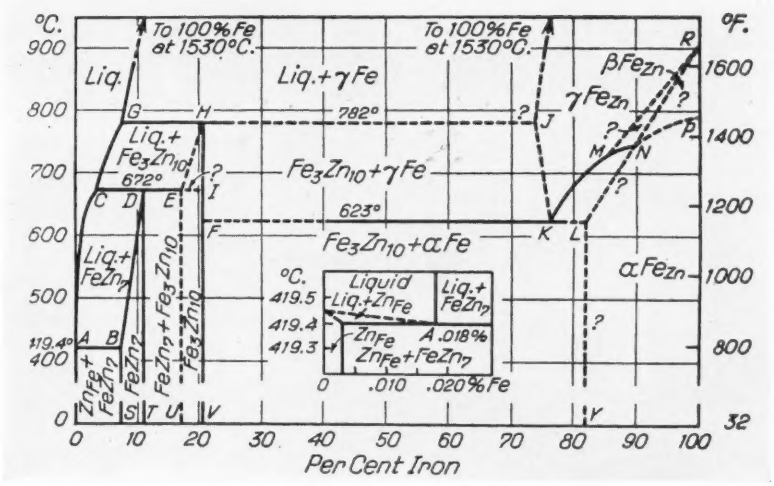



Fig. 1. Iron—Zinc Equilibrium Diagram.

✦ ✦ ✦

## Effect of Size of Strip

STRIP of greater width and of greater thickness tends to spot much more readily than very thin narrow strip. The strip which tends to spot most readily is that which has the least amount of galvanized surface per unit volume of metal. As will be referred to again later, rate of cooling is an important factor in the prevention of spots; large or heavy section strip cools much slower and is much more susceptible to spotting.

✦ ✦ ✦

## Effect of Room Temperature

IT was observed that spotting occurred less in cold weather than when it was warm and that wind effects helped to eliminate spotting. As a result a large fan was installed to circulate air across the strip as it emerged from the spelter. The current of air thus created freezes the molten zinc on the strip and eliminates spots. However, such rapid cooling has a tendency to make the coating brittle and will flake off when the strip is bent.

✦ ✦ ✦

## Theoretical Principles Involved

FROM a consideration of the equilibrium diagram for Fe and Zn shown in Figure 1, it is readily understood that zinc will dissolve in iron by virtue of its solubility, and as the limit of solubility is reached, a series of iron-zinc compounds are formed which exist as separate phases in a matrix of iron saturated with zinc. The alloying action mentioned above constitutes the fundamental basis for the consideration of spot formation.

✦ ✦ ✦

A THIN zinc coating over a surface of cleaned steel will diffuse into the steel base if given sufficient time and held at a temperature high enough where this diffusion proceeds with a fair degree of rapidity. In other words, equilibrium is not reached and therefore diffusion persists as long as there exists a concentration gradient of zinc between the outer surface and the interior of the base metal. It is therefore apparent that any set of conditions which tend to produce a thin coating such as slow emergence from the spelter to promote drainage from the surface, short immersion time in the spelter, and fairly high temperature to increase the fluidity of the zinc to further facilitate drainage, together with other conditions designed to accelerate diffusion of the aforesaid thin layer of zinc such as high temperature of the emerging strip and a warm still mill temperature to hinder the freezing of this top layer, will produce gray spots.

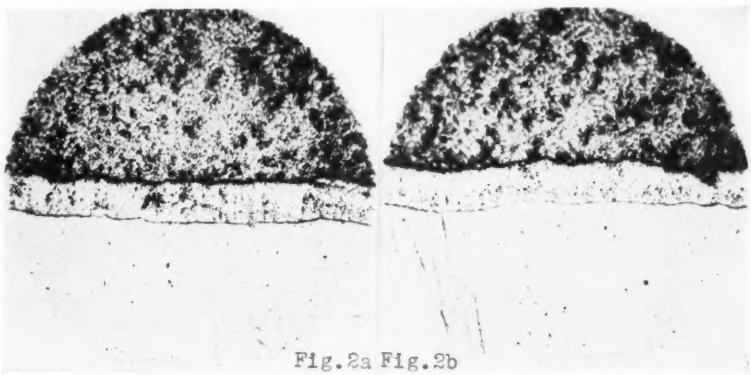
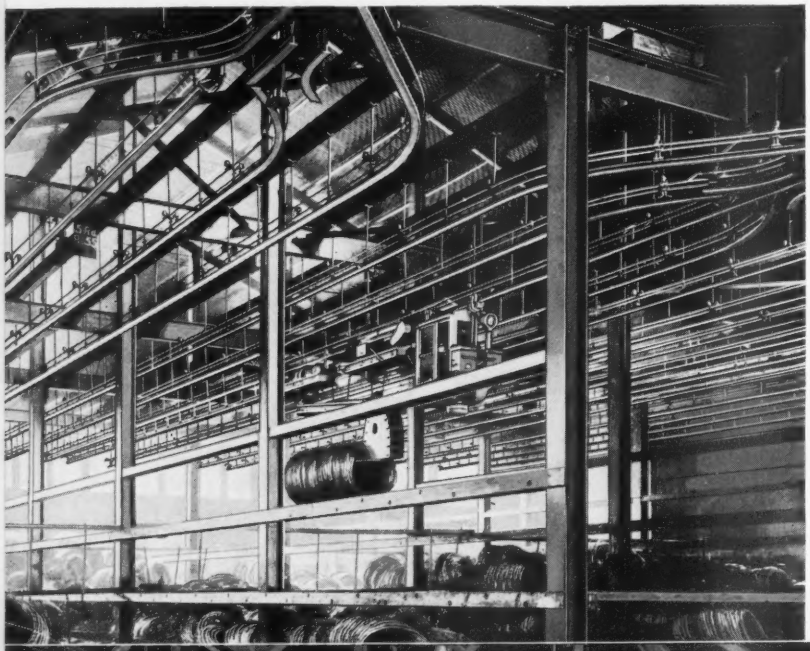



Fig. 2a. Microstructure of coating at spotted area shows coating consisting entirely of iron-zinc alloy layer with no pure zinc layer, X 150.

Fig. 2b. Microstructure of coating at spotted area, X 150.

✦ ✦ ✦

THE experimental evidence indicates that a spot is merely an area on the article where

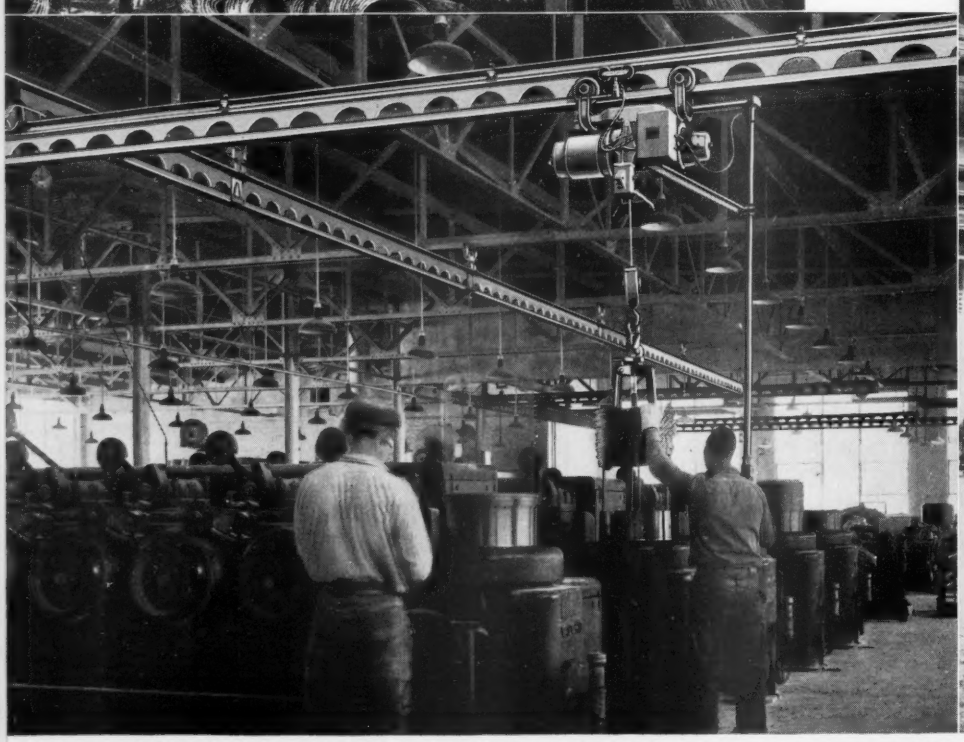


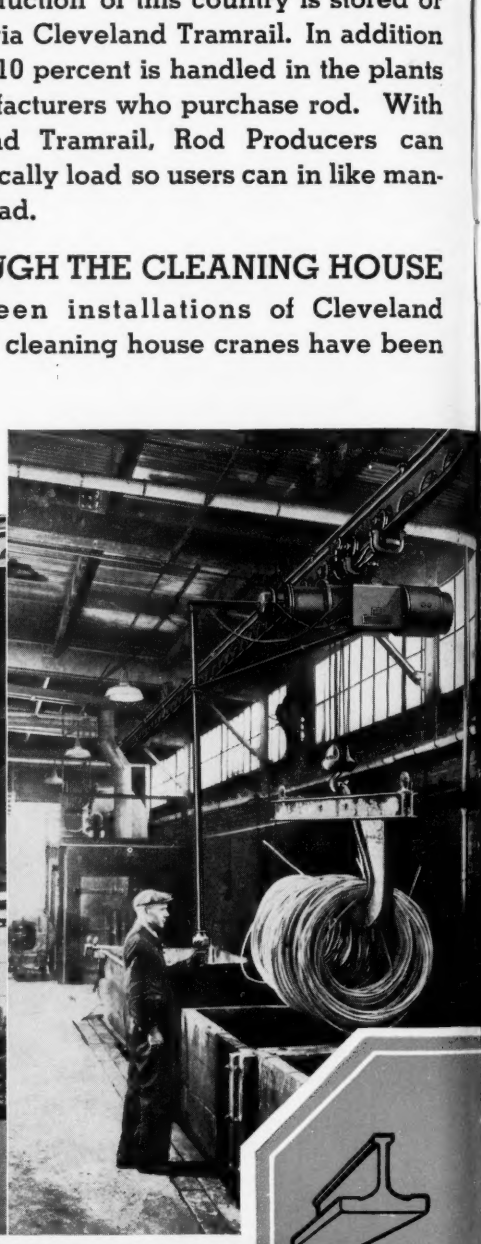
## FOR STORAGE AND SHIPPING

• Approximately 35 percent of the basic rod production of this country is stored or loaded via Cleveland Tramrail. In addition another 10 percent is handled in the plants of manufacturers who purchase rod. With Cleveland Tramrail, Rod Producers can economically load so users can in like manner unload.

## THROUGH THE CLEANING HOUSE

• Eighteen installations of Cleveland Tramrail cleaning house cranes have been sold.







# CLEVELAND TRAMRAIL

# OVERHEAD MATERIALS HANDLING EQUIPMENT

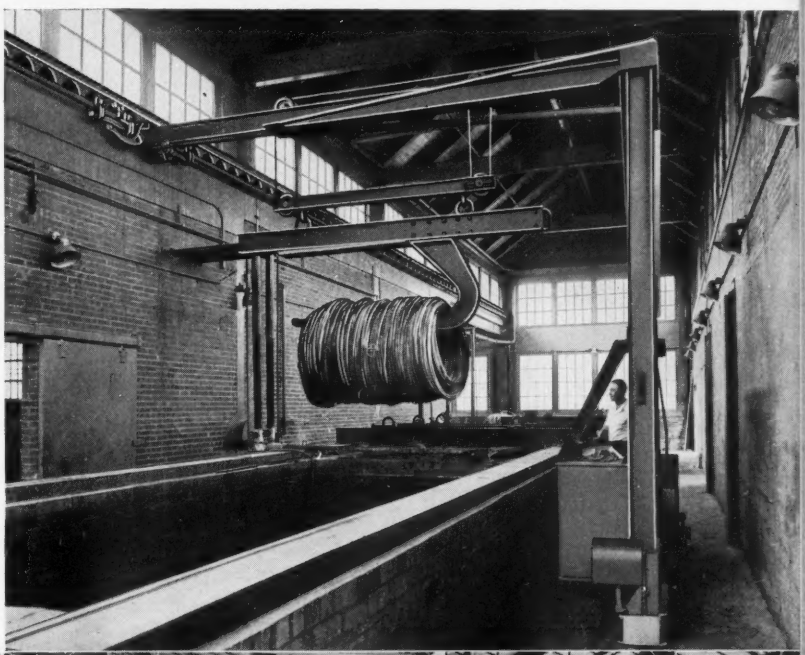
CLEVELAND
All Types for Every Industry
CRANES

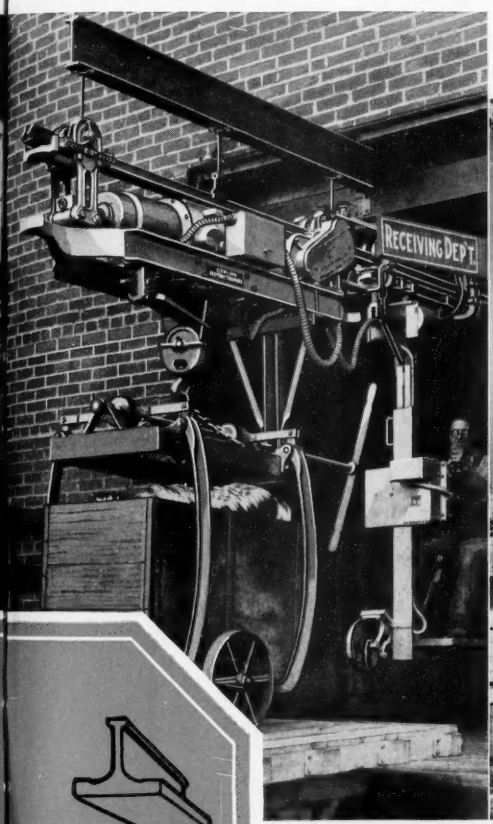
## FOR BLOCK STRIPPING

• Many installations of block stripping cranes and carriers totalling hundreds of such units are in operation, over one hundred in some plants. The most easily propelled crane; fast, snappy hoists with rigid arm push-button control. Hoist can be turn table mounted for ready service of draw blocks on both sides of an aisle.

## PROCESSING

• There is Cleveland Tramrail equipment suitable for all branches of the wire industry. Galvanizing, fence, nails, bolts, etc.





CLEVELAND TRAMRAIL

DIVISION OF

THE CLEVELAND CRANE & ENGINEERING CO

1141 Depot St.

WICKLIFFE, OHIO

# IN THE WIRE AND THE WIRE PRODUCTS INDUSTRY

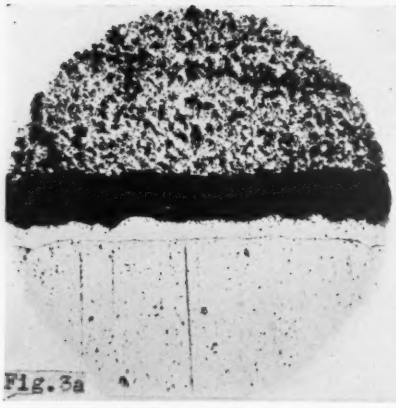



Fig. 3 a. Microstructure of coating on spangled area of same strip shown in Figures 2a. and 2b., X 150.

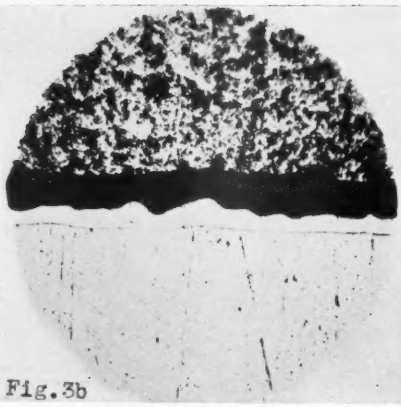



Fig. 3b. Same as Figure 3a.

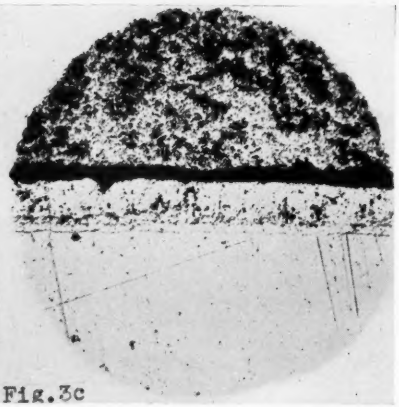
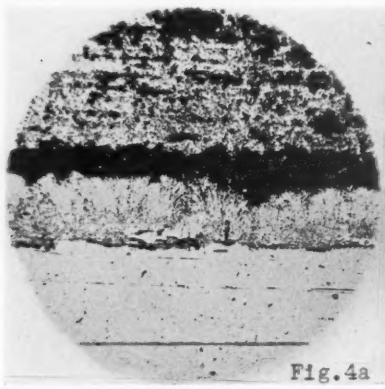



Fig. 3c. Coating having very thin zinc layer over predominating alloy layer, this surface had only a slight spangle, X 150.



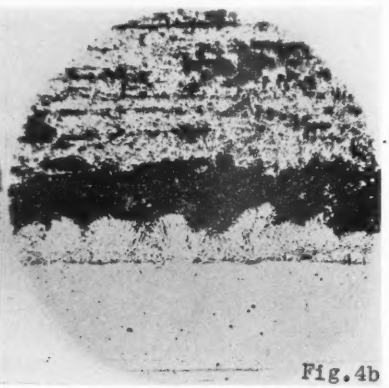




Fig. 4a. Typical zinc coating consisting of pure zinc layer over alloy layer, surface bright with spangled appearance, X 150.

Fig. 4b. Same as Figure 4a.

the bright, spangled zinc-layer has diffused into the base metal below leaving the dull gray-colored zinc-iron alloy layer. Figures 2a and 2b show typical microstructures of a galvanized coating at which areas gray spots occurred. Figures 3a and 3b show the typical microstructures obtained on other portions of the same strip where no spotting occurred and at which places the coating had a bright spangled finish. Figure 3c shows the microstructure of the strip at which point the finish although bright, had an indistinct spangle.

✦ ✦ ✦

THE spot will be seen to consist entirely of iron-zinc alloy layer whereas the other portion of the strip which was not spotted showed its microstructure to consist of a layer of pure zinc over the alloy layer, this latter named structure being normal for all spangled zinc coatings. A typical characteristic structure for a heavy zinc coating is shown in Figures 4a and 4b in which is noted relatively heavier coatings than is commonly applied in commercial galvanizing.

✦ ✦ ✦

FIGURES 5 and 6 show the general appearance of a spot as it occurs on galvanized strip. The spotted area is confined to the central portion where cooling is slowest. Edges rarely show spotting since the zinc at these portions is cooled faster thereby preventing the inward diffusion of the top layer of pure zinc which will eventually spangle as it freezes. Ordinarily, spotting is intermittent due to slight "chattering" or variation in speed of the strip as it emerges causing a slight ripple at the surface of the molten spelter which in turn causes differences in the amount of top layer zinc at these areas. The molten zinc as it drains down on the strip varies in amount and thickness so that spotting occurs where this top layer is thin and does not drain uniformly over the surface.

✦ ✦ ✦

AS a preliminarly experiment to illustrate the effect of this inward diffusion of zinc into the steel base, galvanized steel strip was ex-

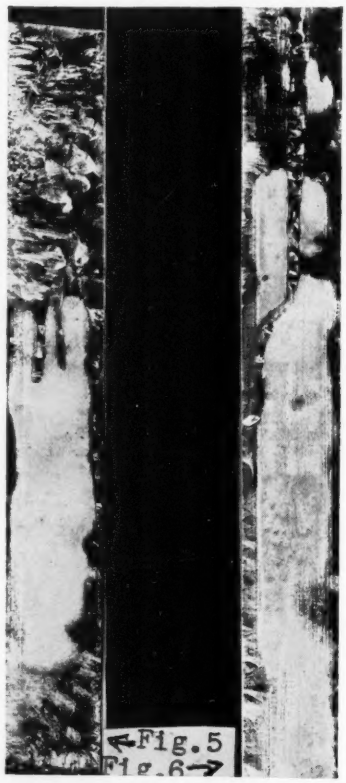



Fig. 5. Strip shows gray spot in center, reduced ⅓.

Fig. 6. Another typical view of a gray spot, reduced ⅓.

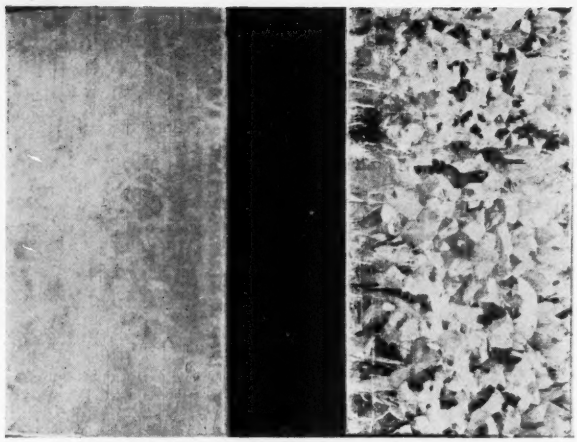


Fig. 7a. Original spangled surface on right, after annealing in absence of air 1000°F. on left, reduced ⅓. ✦

Fig. 8. Gray spots occurring on same steel shown in Fig. 5 after galvanizing for one minute, shows a network spot originating at spangle boundary, reduced ⅓.

Fig. 9. Same as Fig. 8, same steel as shown in Fig 6, reduced ⅓. ✦

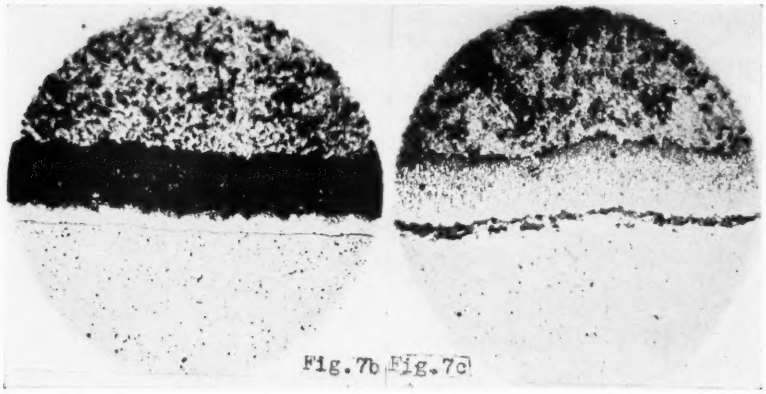
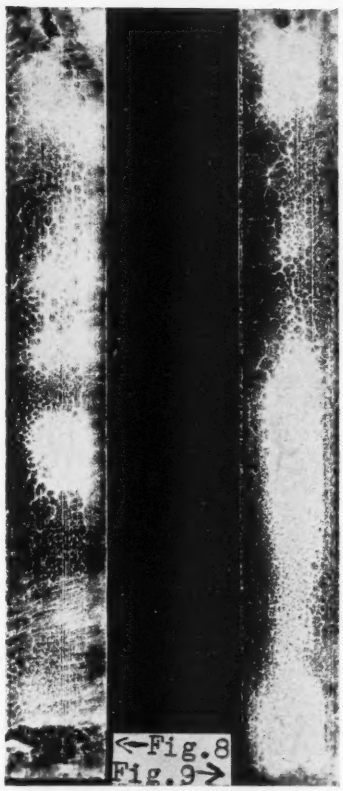



Fig. 7b. Microstructure of spangled coating showing zinc layer over alloy layer, X 150.

Fig. 7c. Microstructure of gray annealed coating consisting practically entirely of iron-zinc alloy layer, X 150. ✦ ✦ ✦ ✦ ✦ ✦ ✦



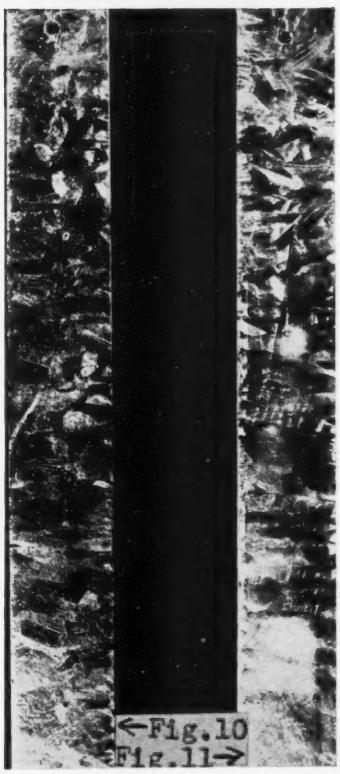




Fig. 10. Non-spotting type of steel galvanized under same conditions as steels shown in Figs. 5 and 6, reduced ⅓.

Fig. 11. Shows non-spotting type of steel (slightly spotted) galvanized under same conditions as steels in Figures 5 and 6, reduced ⅓. ✦

amined photomicrographically before and after annealing at 1000 degrees F. in absence of air. Figure 7a shows the spangled strip as galvanized compared with the appearance of the same strip after annealing. Figures 7b and 7c show the microstructures of the spangled and dull gray coatings respectively. These are consistent with the other figures shown above.

✦ ✦ ✦

## Effect of Time in Spelter

THE effect of time was determined by galvanizing strips of steel which were known to have spotting tendencies. Figures 5 and 6 show the size and nature of the spots formed after galvanizing for fifteen seconds at 850 degrees F. The spots are very large and uniformly dull gray in color.

✦ ✦ ✦

FIGURES 8 and 9 show the spotting that occurred on the same steels shown in Figures 5 and 6 after galvanizing for one minute under the same conditions as for the previous samples. In these latter instances the spots are smaller and in general less distinct due to the increased amount of zinc in the coating which tends to decrease spotting as previously mentioned. Another characteristic of the type of spots obtained when the samples are galvanized for longer periods of time is that quite often the spot will be of a net-work type, that is, the gray spotting tendency will first be noted along the edges of the individual spangles. The large spots will usually have a fringe of these net-work spots at the borders, showing that spotting is actually a diffusion process and that the portions having the thinnest top layer of pure zinc are most susceptible to spotting. This will be referred to again later in the discussion.

FIGURES 10 and 11 show the spotting that occurred with steels Nos. 12 and 2, galvanized at 850 degrees F. for fifteen seconds. These figures compared with Figures 5 and 6 show the great differences in galvanizing characteristics of the various steels referred to in the data.

✦ ✦ ✦

## Effect of Temperature

INCREASED temperature ordinarily has two effects which tend to counteract on another. The increased fluidity at higher temperatures causes the zinc layer to drain more completely forming a thinner coat which is susceptible to spotting. However, the increased amount of zinc in the coating due to conditions favoring increased diffusion of zinc into the steel base saturates the top portions of the steel strip to a greater extent causing the rate of diffusion of zinc from the top layer to be decreased due to a smaller concentration gradient of zinc through these same top areas. In other words, the possibility for the disappearance of the final top layer of pure zinc is diminished since the diffusion of this top layer must progress into the near surface layers of the steel saturated or partly saturated with zinc, which have increased in thickness, thereby cutting down concentration gradient and therefore the diffusion rate into these areas. The diffusion is slowed down to the extent that the top layer freezes and spangles before it has sufficient time to penetrate completely into the base metal. Temperatures below 830 degrees F. show decreased fluidity so that samples galvanized below this temperature show less spotting than those galvanized at 860 degrees F. Increasing the temperatures to 890 degrees F. and above did not show increased spotting tendencies for reasons mentioned above; namely, that the increased amount of zinc in the coating due to the high temperature overbalanced the effects of drainage and longer cooling time. The width and thickness of the strip determines the rate at which the strip will cool, and form a spangled surface; the heavier strip having greater heat content will necessarily cool slower and increase the possibility for spotting. Heavy strip then, will show greatly increased spotting tendencies over thinner strip of the same type of steel, this being due to the retaining of high temperatures longer for the heavy strip providing increased time for diffusion and subsequent spotting. In commercial galvanizing of strip of thickness in excess of 12 gauge, temperatures are maintained in a range approximately 815-830 degrees F.

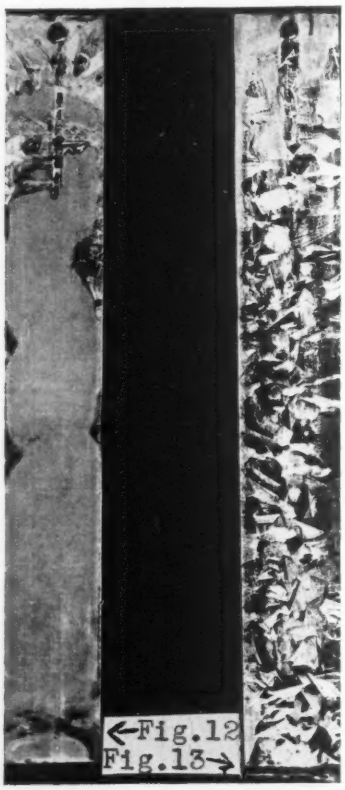



Fig. 12. Shows effect of slow withdrawal of sample from spelter, almost entirely spotted, reduced ⅓.

Fig. 13. Shows effect of rapid withdrawal of same steel shown in Fig. 12, slightly spotted near top only, reduced ⅓. ✦ ✦ ✦

✦ ✦ ✦

## Effect of Rate of Withdrawal From Spelter

VERY slow withdrawal of an article from the surface of the spelter greatly increases spotting tendencies. Figure 12 shows the effect of galvanizing a steel strip of known spotting tendencies which was withdrawn slowly from the spelter; large spots are very prominent. Figure 13 shows the same steel galvanized the same period of time under identical conditions, namely, 15 seconds immersion at 850 degrees F., withdrawn rapidly from the spelter. In the latter instance the spotting is considerably less. This is due to the fact that rapid withdrawal did not permit as complete drainage of zinc from the surface and a thicker coating resulted which froze before it had the opportunity to diffuse into the base metal and thereby form a spot. The drainage effects mentioned are easily observed in the continuous galvanizing of strip where the molten zinc runs down the surface in distinct layers or waves and is much more pronounced where the strip speed through the spelter is high. The actual amount of zinc on the samples mentioned above was 1.012 ounces per square foot for the spotted sample as compared with 1.258 ounces per square foot for the non-spotted specimen. The

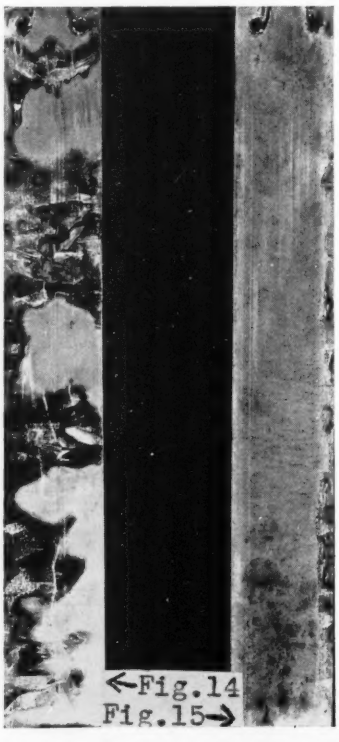



Fig. 14. Top side of strip withdrawn slowly at a 45° angle from surface of spelter (sample withdrawn vertically, held at 45° angle) partly spotted, reduced ⅓.

Fig. 15. Bottom side of same strip shown in Fig. 14, entire surface spotted, reduced ⅓. ✦

method of obtaining the amount of zinc coating will be described later.

✦ ✦ ✦

## Effect of Position of Strip During Withdrawal

TO illustrate further the effect of drainage as affected by the slope of the strip as it emerges from the spelter, a sample strip of a spotting type of steel was galvanized for 15 seconds at 850 degrees F. and withdrawn slowly from the spelter at an angle of 45 degrees. Figures 14 and 15 show the top and bottom sides respectively. It is to be noted that the top side showed but few spots whereas the bottom or underside which drained off its top zinc layer more completely showed spotting over the entire side of the strip.

✦ ✦ ✦

## Weight of Zinc Coating by the Strip Test

THE hydrochloric acid-antimony chloride method for determining the weight of the zinc coating has been designated as standard by the American Society For Testing Materials. Briefly it consists of removing the zinc coating from an accurately measured and weighed sample by immersion in concentrated hydrochloric (sp. gr. 1.19) to which has been added 5c.c. of antimony chloride solution to each 100 c.c. of acid. The antimony chloride solution is prepared by dissolving 20 grams of antimony trioxide in one liter of concentrated hydrochloric acid and is used to inhibit the attack of the acid upon the base metal when the coating has been removed.

✦ ✦ ✦

STRIP tests were run on the whole series of steels to determine the coating characteristics of spotting and non-spotting steels. The results are shown in tables I to X inclusive.

✦ ✦ ✦

FROM Table I several important facts are to be noted. The samples which showed the greatest amount of spotting had the greatest amount of zinc in their coatings. Samples which showed little or no spotting had considerably less zinc although they were all pickled and galvanized under identical conditions. These facts further indicate that rate of diffusion of zinc into the base metal is a primary cause of spotting since all of the spotting steels noted above have greater amounts of zinc which is due to the combined effect of the alloying action while the steel is immersed in the spelter plus the top layer of zinc which is acquired when the strip is withdrawn. The high diffusibility of the zinc for the spotting steels accounts not only for the total heavier coat but also for the diffusion and subsequent spotting of the final top layer of zinc. On the other hand the non-spotting steels do not acquire zinc as fast by the alloying or diffusion process consequently the coating is lighter as regards to zinc and the tendency for the final zinc layer to diffuse into the base metal below is so much less that this top layer freezes and spangles before enough zinc has diffused or alloyed with the steel to form a spot. The mechanism for the formation of spots therefore seems to be a result of the increased diffusibility inherent in a certain class of steel causing the molten top layers of pure zinc to penetrate into the steel to form alloy layers at the expense and elimination of the top layer, leaving only the non-spangled gray-appearing alloy zinc layer at the surface.

✦ ✦ ✦

IT has been observed in commercial operation as well as with small test samples that the spot does not appear until quite some time after the article has been withdrawn from the galvanizing pan. This means that as long as the strip is hot enough to keep the top layers molten, the zinc is still penetrating the base metal and continues to do so until it has reached its freezing temperature or until it has entirely diffused into the steel base. Thus, larger sections tend to spot more readily since they retain their high temperatures a longer period of time.

✦ ✦ ✦

TABLE II, shows results of tests obtained on the same series of steels reported upon in Table I galvanized under identical conditions except for a shorter time interval in the spelter.

TABLE I

| | |
|---|---|
| Temperature Spelter: | 850° F. |
| Total Immersion Time: | 25 seconds. |
| Test Specimen: | 1¾ x 18 gauge strip, 12" length. |
| Miscellaneous: | Aluminum added to spelter, slow withdrawal of samples. |

| Steel No. | Weight of Zinc Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 1 | 1.040 | Two very small spots on both sides; remainder spangled, surface smooth. |
| 2 | 1.100 | No spots, good spangle on one side, less distinct spangle on other side, surface smooth. |
| 3 | 1.176 | Several fairly small spots on one side, other side had no spots, fairly good spangle. |
| 4 | 1.200 | One side badly spotted, other side showed several very small spots. |
| 5 | 1.222 | Several large spots on one side; several smaller spots on other side. |
| 6 | 1.239 | Large spot on one side (70% total area), several smaller spots on other side. |
| 7 | 1.245 | Very large spots on one side, fairly large spots on other side. |
| 8 | 1.271 | Very large spot on one side (80% total area), other side had two small spots. |
| 9 | 1.314 | Fairly large spots on both sides. |
| 10 | 1.322 | Very badly spotted on one side (entire side), smaller spots on other side. |

RESULTS from Table II are consistent with those of Table I and bring out the important relationship between the amount of zinc in the coating and the spotting tendency. Two additional steels were tested, Nos. 11 and 12; No. 12 being very decidedly a non-spotting type steel.

TABLE II

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 15 Seconds. |
| Test Specimen: | 1¾ x 18 gauge, 12" length. |
| Miscellaneous: | Aluminumin the spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 12 | .918 | No spots on either side, bright with distinct spangle. |
| 1 | .916 | No spots on one side, distinct spangle; other side had very small spot near top, smooth. |
| 2 | .934 | No spots on one side, distinct spangle, smooth and bright, other side had several small spots. |
| 3 | .972 | Small to medium sized spots on both sides, portions not spotted had indistinct spangle, not as bright as preceding samples. |
| 11 | 1.025 | Small spot on one side, large spots on other side. |
| 4 | 1.031 | Large spots on both sides. |
| 5 | 1.040 | Large spot on one side (larger than above), small spots on other side, very indistinct spangle on unspotted areas. |
| 8 | 1.071 | Large spots on both sides. |
| 7 | 1.095 | Large spots on both sides, larger than No. 8. |
| 6 | 1.105 | Large spot on one side, medium to large spot on other side. |
| 10 | 1.117 | Large spots on both sides. |

TABLE III

| | |
|---|---|
| Temperature of Spelter: | 850 Degrees F. |
| Total Immersion Time: | 1 Minute. |
| Test Specimen: | 1¾ x 18 gauge, 12" Length. |
| Miscellaneous: | Aluminum in spelter bath, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 12 | 1.153 | No spots on either side, bright fairly distinct spangle, very slight streaks along edges, best sample. |
| 2 | 1.742 | No spots either side, indistinct spangle, very slight streaked. |
| 1 | 1.800 | Very small network spot on one side, no other spots, not as bright as preceding samples, very indistinct spangle, slightly streaked. |
| 3 | 1.835 | Fairly large spot on one side, slight spangle on other side, streaks prominent. |
| 5 | 1.849 | No spots but very streaked, dull finish, spangle barely discernible. |
| 11 | 1.971 | Very small network spots on one side, other side fairly bright, streaked with indistinct spangle. |
| 4 | 2.170 | Large spots on both sides, side with smaller spot prominently streaked, network spot along streaks. |
| 6 | 2.178 | Fairly large spot on one side, smaller spots on other side, badly streaked, very indistinct spangle. |
| 7 | 2.250 | Large spot on one side, small network spots on other side, streaked. |
| 8 | 2.320 | Fairly large spot on one side, smaller network spots on other side, streaked. |
| 10 | 2.360 | Small spots on both sides, partly of network type, prominently streaked, spangle barely discernible. |

✦ ✦ ✦

TABLE III shows results obtained by galvanizing these same steels for a longer period of time, namely, one minute. This immersion time is considerably longer than employed in commercial galvanizing of this type of product, nevertheless important differences were brought out in this test and the coating differences shown to a greater degree.

✦ ✦ ✦

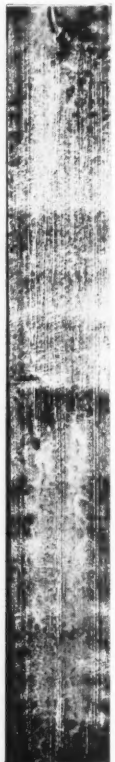


Fig. 16

Fig. 16. Streaking with increased roughness of surface resulting from prolonged immersion in spelter, particularly at high temperatures, reduced ⅓. ✦

WITH longer immersion times we note that spotting occurs to a lesser extent with roughness due to streaks becoming more prominent as shown in Fig. 16. The spotting is consistent with results obtained under other conditions and reported in Tables I and II, namely, that spotting is associated with the heavier coatings. The network type of spot is the more prevalent type when the samples are galvanized for long periods of time. As previously mentioned the network is in reality an outline of the individual spangles which are smaller for the long time samples giving the spot a mottled effect. The total area of the spots obtained after long time immersion is less than for the shorter periods. The amount of zinc at the edge of a spangle is less than the amount within the crystal; therefore, the diffusion of zinc will first be noted at these areas. In the case of shorter immersion times, the zinc diffuses into the base metal

more rapidly so that this phenomenon is not observed. However, for longer immersion times the surface of the steel becomes more and more saturated with zinc so that the rate of diffusion into the steel becomes slower with the result that the final top layer disappears more slowly causing less total spotting, and a spot of the network type. The Preece or copper sulphate immersion test was used to demonstrate the thinness of the coating at the spangle boundaries. Failure of the coatings by means of this test occurs invariably at the spangle boundary, indicating lesser amounts of zinc at these points. This difference can also be noted by visual observation with any kind of a stripping test.

✦ ✦ ✦

STEEL Nos. 4 and 6 spotted more than steel No. 10, although the latter had more zinc in its coating. This is not consistent with previous results but may be accounted for as being the result of saturating the steel surface beyond a certain critical amount so that the final top layer could not be absorbed due to the already large amount of zinc present due to the initially high diffusion rate.

✦ ✦ ✦

TABLE IV shows results obtained by increasing the immersion time to two and one-half minutes, all other conditions being the same as for Tables I, II and III.

✦ ✦ ✦

THE high values of weight of zinc per sq. ft. are due somewhat to the roughness of the surface which did not permit drainage of the zinc, nevertheless tremendous differences are to be observed particularly in the case of steel No. 12 and the others. It is important to note that spotting did not occur, this being due to the fact that the surface of the steel was saturated with zinc so that very little diffusion of the final top layer could take place. The roughening of the surface and the high amounts of zinc are evidence to the fact that considerable alloying action took place and was consistent with regard to the particular type of steel; that is, spotting or non-spotting. None of the samples showed spangled finishes due to the roughness of the surfaces excepting Sample No. 12, which did show a very slight spangle but not nearly as distinct as for the shorter immersion times.

TABLE IV

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 2.5 Minutes. |
| Test Specimen: | 1¾ x 18 gauge, 12" Length. |
| Miscellaneous: | Aluminum in the spelter, samples withdrawn slowly. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 12 | 1.362 | No spots, bright, smooth, very slightly streaked near edge. |
| 2 | 2.621 | No spots, bright, slightly more streaked than No. 12. |
| 1 | 2.946 | No spots, bright, streaked more than Nos. 12 and 2. |
| 3 | 3.055 | No spots, streaked, rough. |
| 5 | 3.064 | No spots, streaked, very rough. |
| 4 | 3.100 | No spots, streaked, very rough. |
| 6 | 3.170 | No spots, streaked, very rough. |
| 10 | 3.450 | No spots, streaked, rough. |
| 9 | 3.500 | No spots, streaked, rough. |
| 11 | 3.955 | No spots, streaked, very rough. |
| 7 | 4.260 | No spots, streaked, very rough. |

TABLE V

| | |
|---|---|
| Temperature Spelter: | 890 Degrees F. |
| Total Immersion Time: | 2.5 Minutes. |
| Test Specimen: | 1¾ x 18 gauge strip, 12" Length. |
| Miscellaneous: | Aluminum in spelter; samples withdrawn slowly. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 12 | 1.706 | No spots, bright, smooth, slight spangle. |
| 2 | 2.879 | No spots, rough, streaked, no spangle. |
| 1 | 2.941 | No spots, rough, streaked, no spangle. |
| 9 | 3.440 | Spotted both sides, rough streaks. |
| 7 | 3.861 | Spotted both sides, rough streaks. |

✦ ✦ ✦

TABLE V shows results obtained by galvanizing several samples for long periods of time at high temperatures.

✦ ✦ ✦

HIGH temperature, long time immersion showed remarkable differences in not only the amount of zinc in the coating, but also in the nature of surface. Sample No. 7 had over 100 percent more zinc than sample No. 12 which has shown consistently smoother coatings in all tests with a minimum amount of zinc. Spotting becomes difficult to detect under the conditions employed above since roughness becomes the most objectionable factor and tends to mask the spotting tendency due to the very heavy coatings produced by the rough surface. The roughening is due to the alloying effect on the surface and goes hand in hand with spotting since it is the result of increased diffusion or alloying on the part of the steel base. In commercial galvanizing, however, roughening is not a problem since the usual galvanizing temperatures and immersion times are not conducive to the formation of this type of defect although spotting which is due to the same cause can result.

✦ ✦ ✦

IN order to determine the effect of analysis as regards spotting, several steels of another grade were obtained, rolled into test bars and galvanized with the results shown in table VI.

IT is apparent that neither the phosphorus content nor the carbon content has any particular significance regarding the probability of a steel for spotting, in fact, most commercial galvanizing is concerned with this type of steel, that is, low carbon low phosphorus steel. Here again it is to be noted that the spotting steels had the heavier zinc coatings.

✦ ✦ ✦

TABLE VI

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 30 Seconds. |
| Test Specimens: | 1″ x 1″ Angle Bar, 14″ Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 13 | 1.132 | No spots, smooth, bright, had distinct spangle. |
| 14 | 1.164 | No spots, smooth, bright, spangle not quite as distinct as No. 13. |
| 15 | 1.197 | Slightly spotted, fairly bright, smooth. |
| 16 | 1.262 | Large spots, fairly smooth. |
| 17 | 1.363 | Entire sample bar spotted. |

TABLE VII

| | |
|---|---|
| Temperature Spelter: | 855 Degrees F. |
| Total Immersion Time: | 15 Seconds. |
| Test Specimen: | 1¾ x 18 gauge, 14″ Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 7 | 1.093 | Pickled from scale; large spots both sides. |
| 12 | 1.013 | Pickled free from scale; did not spot, smooth, spangled. |
| 7 | 1.588 | Sandblasted; did not spot, did not spangle, surface slightly roughened. |
| 12 | 1.552 | Sandblasted; did not spot, did not spangle, surface slightly roughened. |

TABLE VIII

| | |
|---|---|
| Temperature Spelter: | 855 Degrees F. |
| Total Immersion Time: | 20 Seconds. |
| Test Specimen: | 1¼ x 1¼ Angles, 14″ Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 13 | 1.068 | Pickled; no spots, bright, spangled. |
| 16 | 1.106 | Pickled; several small spots. |
| 13 | 1.869 | Sandblasted; no spots, no spangle. |
| 16 | 1.889 | Sandblasted; no spots, no spangle. |

TABLE IX

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 15 Seconds |
| Test Specimen: | 1¾ x 18 gauge, 14″ Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 7 | 1.274 | Pickled normally, 3 minutes; spotted both sides. |
| 7 | 1.869 | Pickled two hours in hot acid, spotted considerably less, increased roughness of coating. |

IN order to determine the effect of the method of removing the scale to ascertain whether the pickling operation induces spotting alone for the so-called spotting steels, several samples were galvanized which had been pickled in the usual manner and others which had their surface scale removed by sandblasting. The results are shown in Table VII.

✦ ✦ ✦

SIMILAR tests were conducted on steels Nos. 13 and 16, the results being essentially the same as those obtained above, namely, that the sandblasted specimens did not spot and showed considerably heavier coatings. The results were not contrary to those expected since it has already been noted that whenever the surface coatings become heavy the diffusion rate and therefore the spotting tendency are decreased. The slight roughening of the surface by the sandblast method was sufficient to present increased surface to the alloying action of the spelter and further, prevent the drainage of the top layer of zinc acquired during its emergence from the surface of the molten spelter. It is important to note that no spangle appeared due to the roughening of the sandblasted surfaces.

✦ ✦ ✦

TABLE VIII, shows the results of similar tests on a different class of steel.

✦ ✦ ✦

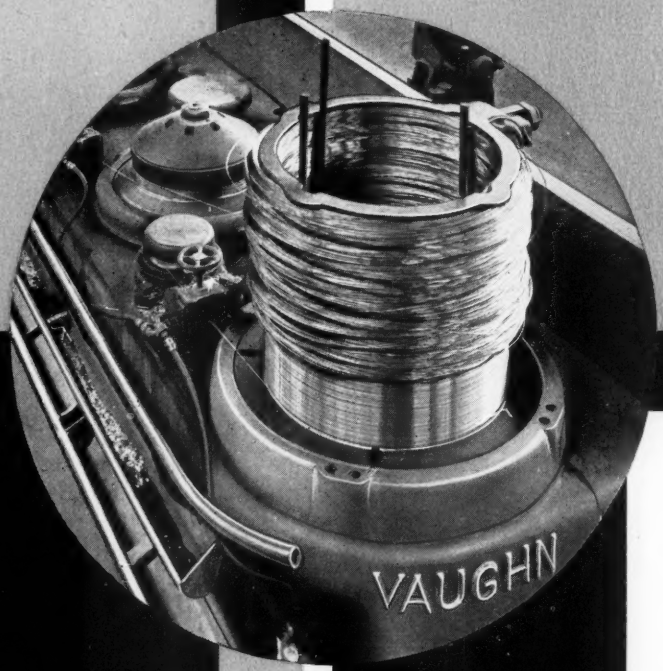
THE sandblasted specimens after galvanizing show a surface which is rougher than the original cleaned surface, whereas, the pickled specimens are considerably smoother. As will be noted again later the tendency for a surface to become rough due to the alloying action is considerably affected by the original surface conditions. Time in the spelter is also an important factor; long immersion times favoring the roughening tendency.

✦ ✦ ✦

THE effect of overpickling in hot, strong acid for a long period of time was observed and the results given in Table IX.

# VAUGHN

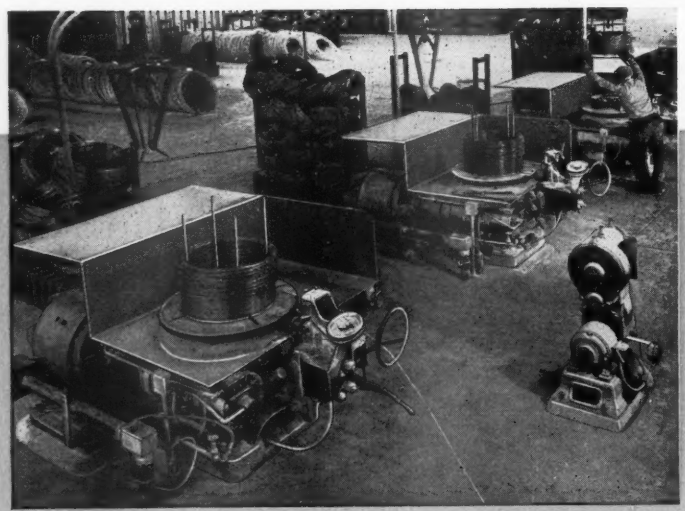
## WIRE DRAWING MACHINERY




**A COMPLETE PROVED LINE OF EQUIPMENT THAT MEETS EVERY REQUIREMENT OF THE MODERN MILL**

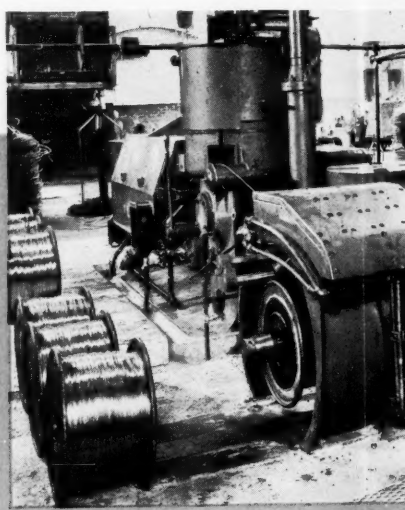
# COMPACT, SAFE, SPEEDY *and* EFFICIENT ...

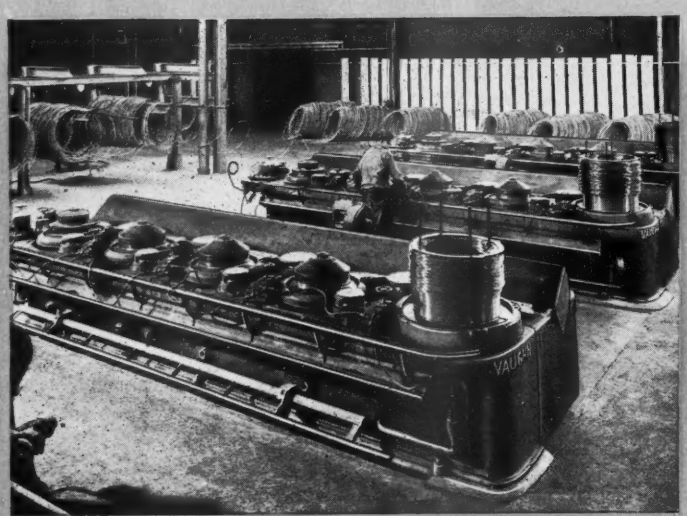
# VAUG
## WIRE DRA
## EQUIPM



**MOTOBLOC**

Available in six sizes for drawing in coils 1" and smaller, with a wide variety of adjustable speed ranges. Single or double deck.





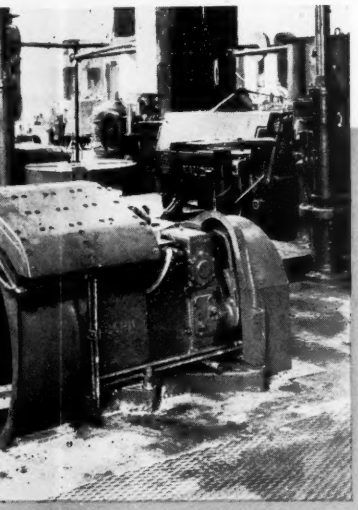
**MOTOBLOX**

A line of non-slip continuous machines: (1) HR Series—from three to seven drafts; normal finishing range from No. 11 to No. 18. (2) HI and HIV Series—from four to seven drafts; normal finishing range from No. 16 to No. 25. (AS&W gauges)

THE VAUGHN MACHINERY COMPA

# GHN
# RAWING
# PMENT

## FOR WET or DRY DRAWING STEEL, COPPER or ALLOYS

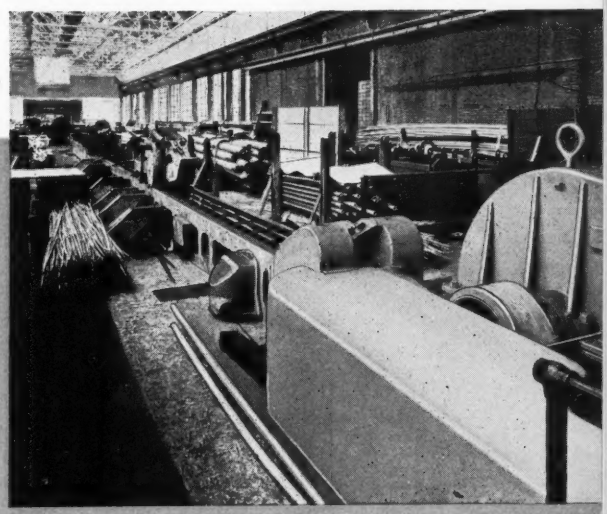


**CONE and TANDEM MACHINES**

For all types of wet-finishing (copper, steel and alloys). Several sizes from rod to finest wire — both coil and spool attachments.

**DRAW BENCHES**

10,000 to 200,000-pound capacity for bars or tubes . . . any required length.

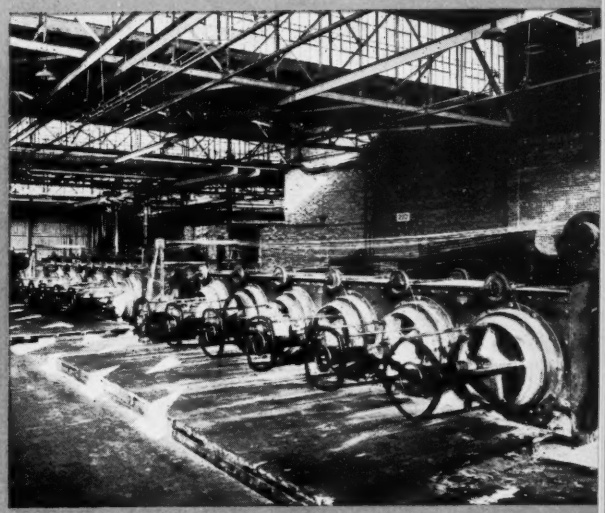


**POINTERS**

Two and four roll pointers available for a wide range of sizes. Photograph shows four-roll pointers and No. 12-22 double deck Motoblocs.

**TAKE-UP FRAMES**

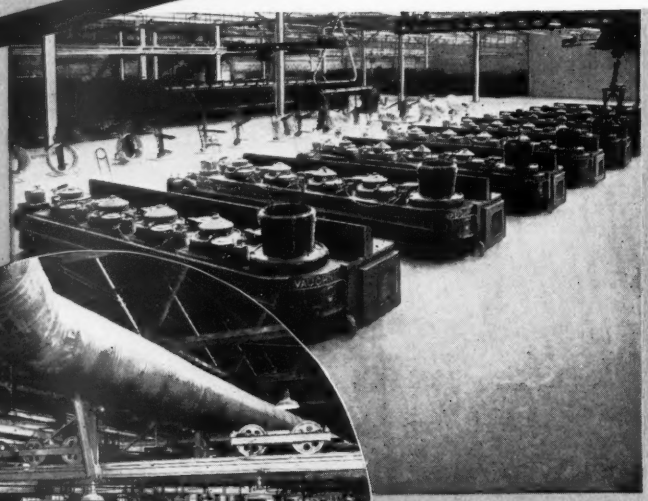
For galvanizing and patenting.

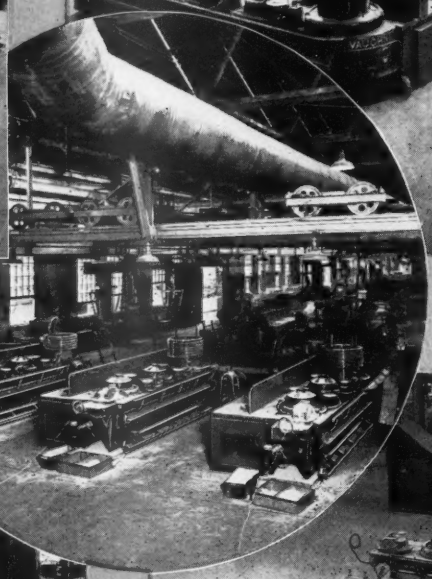


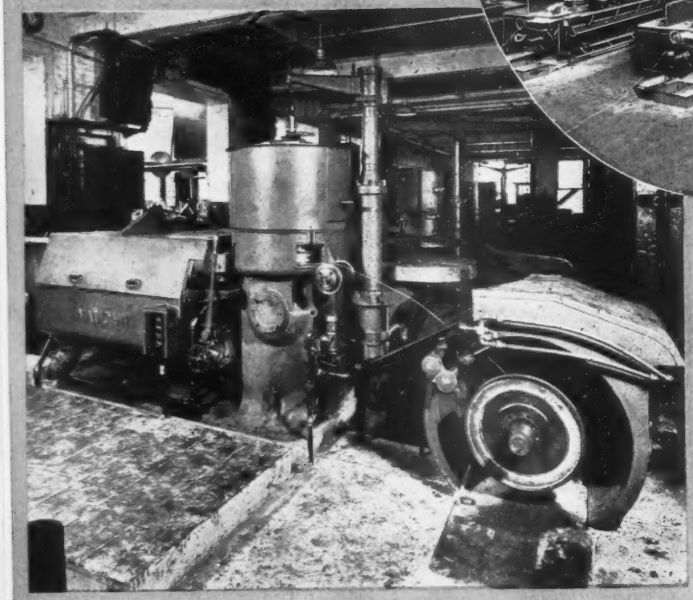
MPANY, CUYAHOGA FALLS, OHIO

*Recent Typical Installations of*

# VAUGHN WIRE DRAWING EQUIPMENT







# VAUGHN

## WIRE DRAWING MACHINERY

ALTHOUGH a commercial inhibiter was used in the pickling solution, the overpickled sample showed the effects of increased acid attack. The slight roughening of the surface being sufficient to increase the amount of zinc in the coating and as is usual the amount of spotting diminished.

✦ ✦ ✦

THE statement has been made by **White** (5) and others, (4), (8); that hydrogen acquired during the pickling process is the cause of spotting and that it is the escape of this hydrogen through the molten zinc just prior to its freezing and spangling to disturb the coating to the extent that spangling does not occur and the surface appears gray. While the mechanism of spot formation has already been shown to be due to a different cause certain tests were conducted on steels whose surfaces were ground smooth and then polished with fine emery paper. These samples were galvanized together with other specimens of the same steels pickled in the usual manner. The results of these tests are shown in table X.

✦ ✦ ✦

DATA presented in Table X indicates that spotting steels retain their spotting tendencies regardless of whether or not they have been pickled in acid. However, the degree of spotting is unquestionably increased by pickling in acid and seems to attain its maximum effect in a relatively short time since overpickling seems to have little or no additive effect. A commercial inhibitor was used in the pickling tanks.

✦ ✦ ✦

APPARENTLY the presence of hydrogen in the steel in some form or other accelerates the alloying action of zinc with the steel, this of course being confined to a particular class of inherently spotting steels and is not common to all steels.

✦ ✦ ✦

IN concluding and summaring the first part of this study, namely, the invesigation of the nature and mechanism of spotting, the following facts may be cited:

TABLE X

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 40 Seconds. |
| Test Specimen: | 2″ x ⅛″, 14″ Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Oz./Sq. Ft. | REMARKS |
|---|---|---|
| 16 | 1.163 | Polished surface—40 to 50% of total area on either side spotted. |
| 16 | 1.308 | Normally pickled surface—80 to 90% total area on either side spotted. |
| 16 | 2.025 | Overpickled, 2¼ hours in hot acid—50 to 65% total area on either side spotted. |
| 14 | 1.080 | Polished surface—no spots, distinct spangle, smooth. |
| 14 | 1.280 | Normally pickled surface—no spots, indistinct spangle slightly roughened, not as bright as above. |
| 14 | 1.840 | Overpickled, 2¼ hours in hot acid—no spots, no spangle, surface roughened. |
| 10 | 1.092 | Polished surface—spotted slightly, slightly roughened with streaks. |
| 10 | 1.669 | Normally pickled surface—fairly large spots on both sides. |
| 10 | 2.076 | Overpickled, 2¼ hours in hot acid; spotted on both sides, roughened, streaked. |
| 12 | 1.041 | Polished surface—no spots, smooth, bright, spangled. |
| 12 | 1.254 | Normally pickled surface—no spots, indistinct spangle, not as bright as above. |
| 12 | 1.460 | Overpickled, 2¼ hours in hot acid; no spots, indistinct spangle, slightly roughened. |

1—Spotting is confined to certain heats or grades of steels.

2—Spotted areas consist of iron-zinc alloy without the usual top layer of zinc which ordinarily displays a characteristic spangle.

3—Spots are formed by the diffusion inward, due to the alloying action, of the pure zinc layer which is on the outer surfaces.

4—Actual conditions under which the galvanizing is being done has important effects in intensifying or diminishing spotting defects.

5—Steels susceptible to spotting invariably show heavier coatings than non-spotting steels galvanized under identical conditions.

6—The increased amount of zinc in the coating and the actual formation of spots are the result of increased rates of diffusion of zinc into the base metal.

7—Pickling in acid to remove mill scale from the surfaces has the effect of increasing spotting tendencies for steels which already show spots after galvanizing the mechanically polished (cleaned) surfaces. Steels not susceptible to spotting with non-pickled surfaces are not prone to spotting when pickled in acid. In other words pickling intensifies a quality already present in the steel.

8—The quality of a zinc coating is not accurately judged by its outward appearance, and that a lack of a spangle is no criterion for rejection of a zinc coated article except where a spangle is necessary to convince a certain class of the trade that the article has been galvanized.

## Metallographic Characteristics of Galvanizing Steel

FROM data already presented it is apparent that spotting is an inherent characteristic peculiar to certain classes of steels. The second part of this paper is an effort to determine some of the metallographic characteristics of such steels and how these qualities are imparted.

✦ ✦ ✦

THE first tests, more or less of a preliminary nature, were concerned with the actual existing grain size of the article to be galvanized. A number of samples were obtained of steel No. 20, the billets having been rolled through the finishing mill at different temperatures. The results of galvanizing these strips are shown in Table XI.

✦ ✦ ✦

A SERIES of tests were run on several other steels in order to determine whether the degree of reduction as accomplished by the rolling of a billet into a smaller

TABLE XI

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 20 Seconds. |
| Test Specimen: | 2½" x ⅛", 14" Length. |
| Miscellaneous: | Aluminum in spelter, slow withdrawal of samples. |

| Steel No. | Heat Treatment | Grain Size | REMARKS |
|---|---|---|---|
| 20 | Finishing temperature 1800° F. | Coarse | Spotted on both sides of strip. |
| 20 | Finishing temperature 1460° F. | Fine to medium | Spotted on both sides of strip. |
| 20 | Finishing temperature 1450-1550° F. Annealed at 1550° F. | Coarse | Spotted on both sides of strip. |

TABLE XII

| | |
|---|---|
| Temperature Spelter: | 850 Degrees F. |
| Total Immersion Time: | 25 Seconds. |
| Test Specimen: | 1" x 1" Angle, 12" Length; billet, ¾" Diameter, 12" Length. |
| Miscellaneous: | Aluminum in the spelter, samples withdrawn slowly. |

| Steel No. | Galvanized Billet, Remarks | Galvanized Angle, Remarks |
|---|---|---|
| 14 | No spots, bright, smooth. | No spots, bright, spangled. |
| 15 | No spots, bright, smooth. | No spots, bright, spangled. |
| 16 | Large gray area or spot. | Large spots on sides. |
| 17 | Large gray area or spot. | Small spots, much less than No. 16 above. |

section had any effect upon the spotting tendencies of these steels. The billets were tested by turning them down in a lathe to a diameter of ¾ inches and length of approximately 12 inches. The results of these tests are summarized in table XII.

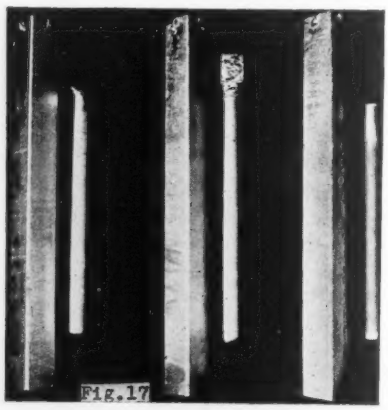



**Fig. 17. Left to right, steel Nos. 14, 15, 16, showing that spotting or non-spotting characteristics are consistent with the heat of steel and are not affected by the degree of reduction (assuming all reductions are accomplished by hot working) reduced ⅛.**

✦ ✦ ✦ ✦

DATA from Table XII show that spotting is not affected by the reduction in cross sectional area and apparently is a quality associated with the nature or type of steel. It is noted here and elsewhere that the spotting tendency can exist to a greater or lesser degree as in the case of steel No. 17 above. This is also to be observed in data contained in Tables II and III and others, in which certain steels while susceptible to spotting, do so to a much lesser degree than others.

✦ ✦ ✦

FIGURE 17 shows steels Nos. 14, 15 and 16 after galvanizing according to the procedure described in Table XII and reveals the spotting tendency of steel No. 16 in both the billet and angle forms.

✦ ✦ ✦

## McQuaid-Ehn Carburizing Test

THE **McQuaid-Ehn** carburizing test was utilized to determine possible differences in inherent grain size and normality which might be traceable back to the Open Hearth furnaces, thereby revealing fundamental differences for spotting and non-spotting steels.

✦ ✦ ✦

IN so far as this investigation is concerned, the results will be grouped into two main divisions: The first including steels Nos. 1 through and including No. 13, the second group including steels Nos. 14, 15, 16, 17, 19 and 20.

✦ ✦ ✦

THE **McQuaid-Ehn** carburizing test gave some very interesting results which proved useful in classifying the steels according to their method of manufacture.

✦ ✦ ✦

## Discussion of Photomicrographs

FIGURE 18 shows the results of the **McQuaid-Ehn** test on steel No. 2, a comparatively non-spotting galvanizing steel. The grain corresponds to No. 1 of the **American Society for Testing Materials** grain size classification which is normally considered a coarse grained steel. The structure as a whole could be considered fairly coarse grained and normal.

✦ ✦ ✦

FIGURE 19 illustrates steel No. 12, a non-spotting type of steel of the highest degree. The grain size is large, in excess of No. 1 of the A. S. T. M. classification. The structure is slightly abnormal as shown by the thickness and irregularity of the carbide envelopes.

✦ ✦ ✦

FIGURE 20 shows steel No. 13 similar in every respect to No. 12 in regard to its carburized structure and galvanizing qualities.

✦ ✦ ✦

FIGURE 21 shows steel No. 3, a steel having some spotting tendencies but not as bad a steel as Nos. 5, 6, 7, 8 or 9 described below. The grain is mixed consisting of large and small grains with the latter predominating, the sizes ranging from No. 1 to No. 3 or 4. The carbide structure is normal.

✦ ✦ ✦

FIGURES 22, 23, 24, 25 and 26 illustrate the microstructures of badly spotting steels. In all

cases the grain size is smaller than the non-spotting steels. The grain size for these steels was approximately No. 3 except steel No. 7 which had a grain size of No. 7. The carbide structures were all slightly abnormal.

✦ ✦ ✦

CONSIDERING the results obtained from the study of the first group of steels, it can be stated that the non-spotting steels had large inherent grain sizes. The normality effects were slight and unimportant as compared with grain size.

✦ ✦ ✦

THE results of the photomicrographic study of the second group are essentially the same except that the difference in grain size is much more pronounced.

✦ ✦ ✦

FIGURE 27 shows steel No. 16 in which is observed a small grain of a highly normal type, more so than any steels observed thus far. This steel was very definitely a spotting type. The grain size corresponds to No. 3 and 4 of the A. S. T. M. classification.

✦ ✦ ✦

FIGURE 28 shows the microstructure of steel No. 14 which has an extremely large grain, slightly abnormal. This steel was a non-spotting type of galvanizing steel. The grain size is in excess of No. 1, being thereby an extremely coarse grained steel.

✦ ✦ ✦

FIGURES 29 and 30 illustrate steels Nos. 17 and 20 which resemble steel No. 16 described above. Here again the structure reveals a fairly small grain, ranging from No. 3 to No. 4, with essentially normal structures. Steel No. 17 did not exhibit quite as great a tendency to spot as steel Nos. 16 and 20.

✦ ✦ ✦

FIGURES 31 and 32 show the miscrostructures of steels Nos. 15 and 19 which, like steel No. 14, are of the non-spotting type. The extremely large grain, in excess of grain size No. 1, is an outstanding characteristic of these steels. The carbide structure is slightly abnormal.

✦ ✦ ✦

## Summary of Results

SUMMARIZING results of the microscopic study, it is apparent that certain marked differences in microstructure exist between the spotting and non-spotting types of steels. The non-spotting steels are characterized by their extremely large grain which in most cases displays slight abnormality. The spotting steels had a much smaller grain size, ranging consistently in the grain size classification from No. 3 to No. 4, with a carbide structure ranging from normal to slightly abnormal. Apparently, then, the grain size effects outweigh the normality effects.

✦ ✦ ✦

## Open Hearth Considerations

INVESTIGATION of the Open Hearth methods in the manufacture of the steels under consideration showed important differences which will be discussed later; at this point it is sufficient to say that the so-called "open steels", that is, steels charged, worked, and deoxidized in such a manner as to leave a great deal of iron oxide in the steel at the time of tapping and therefore very active due to the Fe0 reacting with the carbon in the steel, turned out to be the non-spotting steels. Steels more carefully and completely deoxidized in the furnace and ladle and in general a higher quality steel, as usually considered, turned out to be the spotting type of steels.

✦ ✦ ✦

INVESTIGATION of the methods of manufacture for steels 1, 2 and 3 as compared with the other spotting steels of the same classification revealed the fact that these heats were charged fairly high with scrap, lower in pig iron. Therefore, for a given amount of deoxidizing agents, the amount of Fe0 left in the steel would be correspondingly higher than for the other steels which were charged higher in pig iron, lower in scrap and deoxidized in the furnace to greater degree. These steels while all of the semi-killed type vary in the amount of oxides in the steel, steels Nos. 1, 2, and 3 having greater amounts than the others. The above remarks are also intended to apply to steels Nos. 12 and 13 which are included in this first group.

✦ ✦ ✦

STEELS Nos, 1, 2, and 3 and including all of the spotting steels through No. 11 are of one particular type as regards their usage. They are so-called hoop steels and are made with high phosphorus content, rephosphorized in the ladle, to harden and strengthen the steel. The difference between steels Nos. 1, 2 and 3 and the others of this type was due to certain changes designed to improve the quality. These changes in the manufacture while improving the steel for cooperage purposes, increased the spotting tendencies to a marked degree.

✦ ✦ ✦

STEELS Nos. 12 and 13 included in the first group are made with lower phosphorus and are normally classed as steels of structural quality, intermediate grade. These steels had no-spotting characteristics, and as previously mentioned are made more "open" than steels of the spotting type.

✦ ✦ ✦

STEELS Nos. 14, 15 and 19 were made "open", that is, with a minimum amount of deoxidation in the ladle only whereas steels Nos. 16, 17 and 20 were made with higher pig iron charges, deoxidized in the furnace as well as in the ladle and by comparison a higher quality steel.

✦ ✦ ✦

OPEN Hearth observations showed that the non-spotting steels were charged lower in pig iron, higher in scrap, and have higher ratios of lime (burned to Ca0) to pig iron. This means that such steels will melt down higher in Fe0 content due to the decreased amounts of silicon and manganese present and the increased oxidizing action of a limy slag. Semi-killed

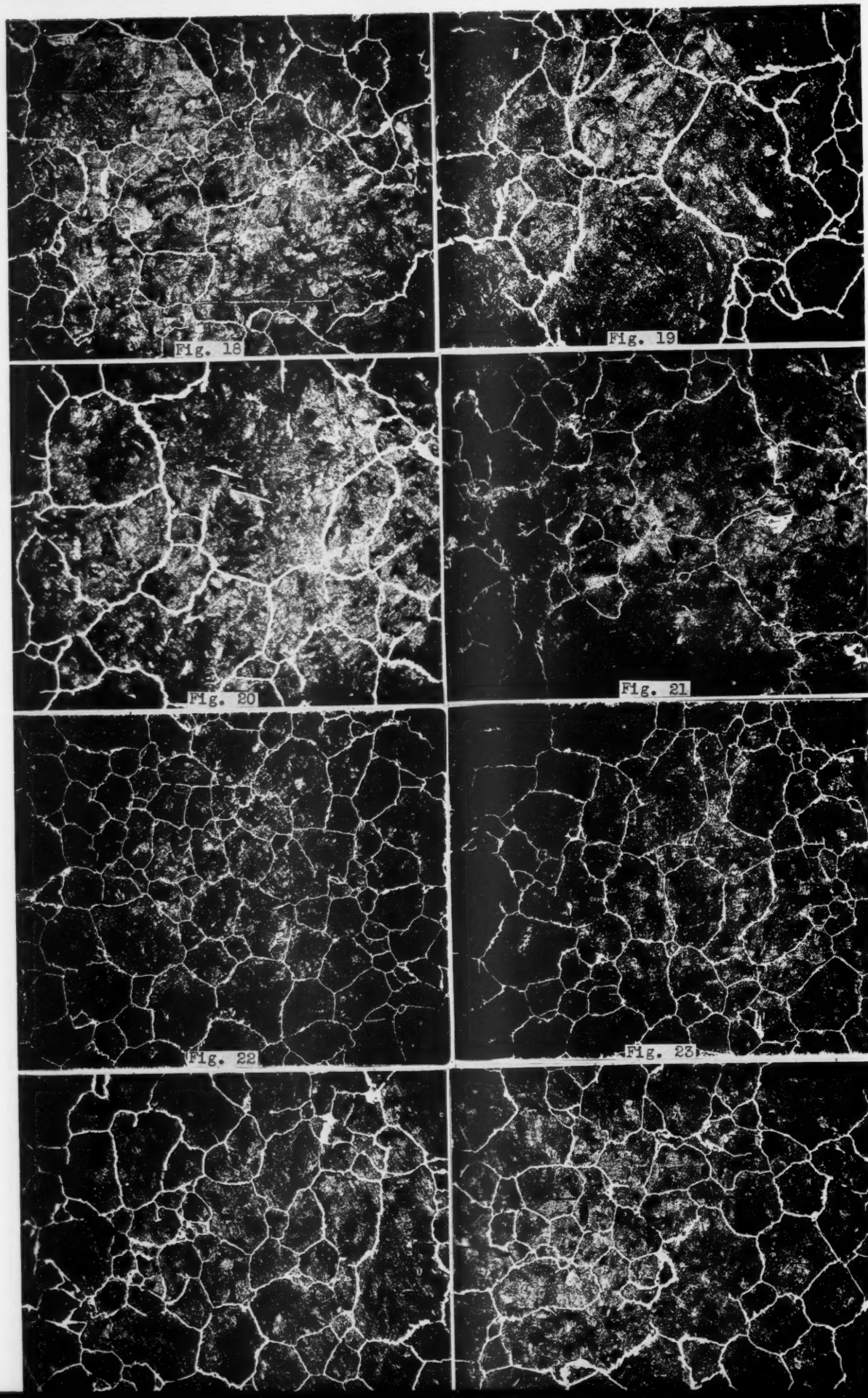


Fig. 18

Fig. 19

Fig. 20

Fig. 21

Fig. 22

Fig. 23

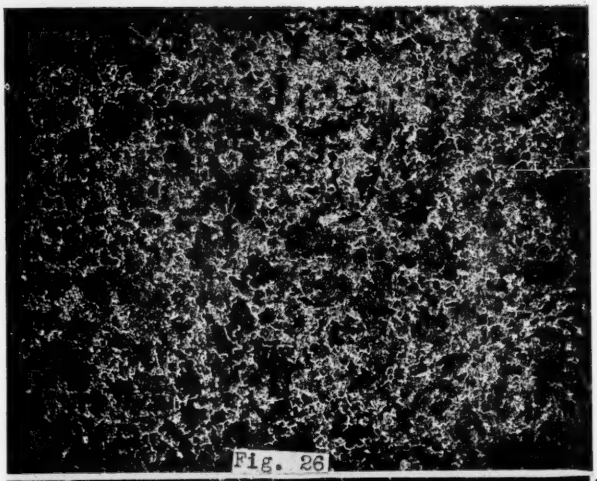


Fig. 26

Fig. 18. McQuaid-Ehn grain size for a comparatively non-spotting type of steel, X 100.

Fig. 19. McQuaid-Ehn grain size for a non-spotting type of steel, X 100.

Fig. 20. Non-spotting type of steel, X100.

Fig. 21. This steel had some tendency toward spotting, X100.

Fig. 22 Badly spotting type of steel, X100.

Fig. 23. Badly spotting type of steel, X100.

Fig. 24. Badly spotting type of steel, X100.

Fig. 25. Padly spotting type of steel, X100.

Fig. 26. Badly spotting type of steel, X100.

Fig. 27. Badly spotting type of steel, X100.

Fig. 28. Non-spotting type of steel, X100.

Fig. 29. Spotting type of steel, X100.

Fig. 30. Badly spotting type of steel, X100.

Fig. 31. Non-Spotting type of steel, X100.

Fig. 32. Non-Spotting type of steel, X100.

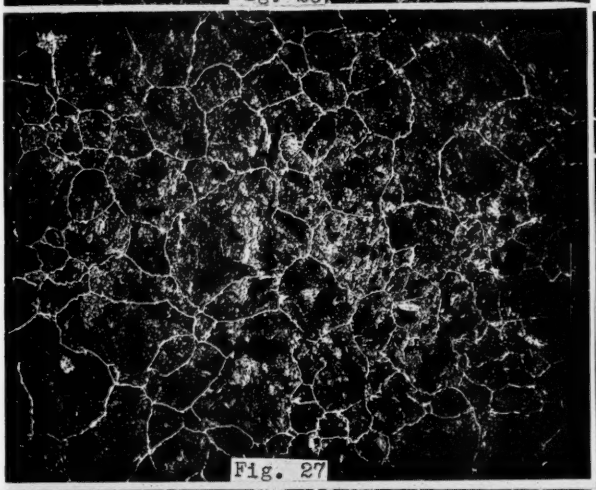


Fig. 27

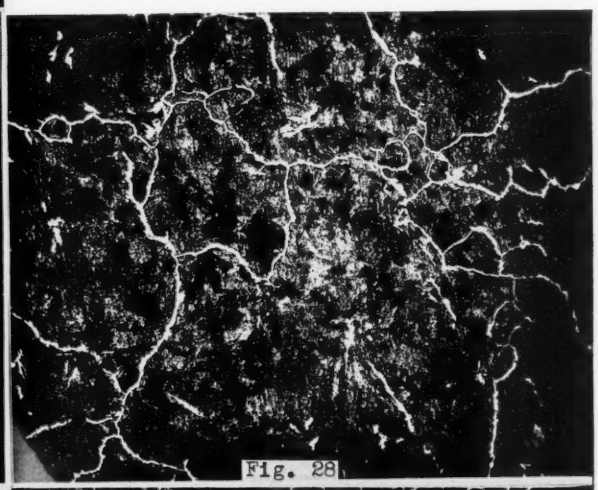


Fig. 28

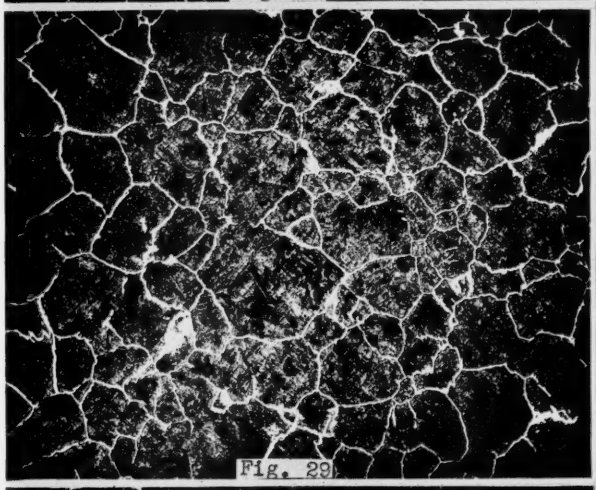


Fig. 29

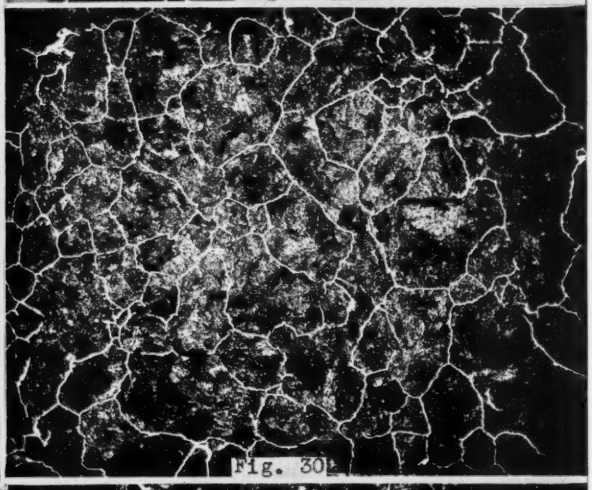


Fig. 30

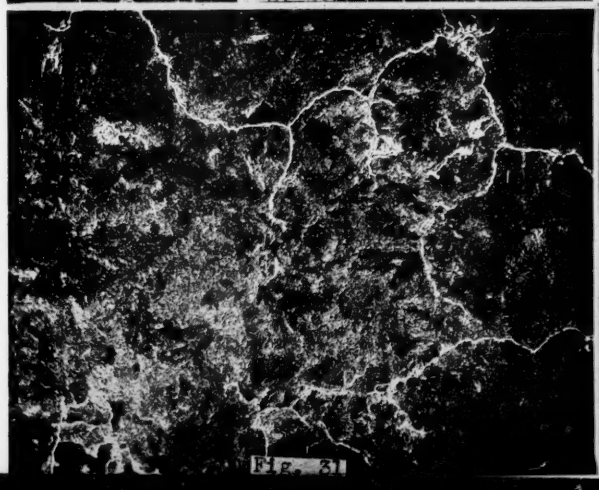


Fig. 31

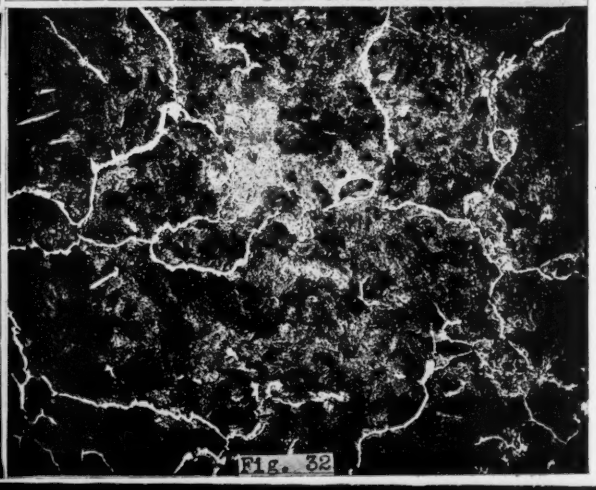


Fig. 32

steels of this type require a handful or two of aluminum shot in the molds.

✦ ✦ ✦

FOR semi-killed steels, just enough iron oxide is desired so that the action between the FeO and carbon will cause the blow holes to be fairly deep-seated and form a minimum amount of pipe in the top part of the ingot. However, it is possible to have steels semi-killed to varying degrees ranging from fairly open steels requiring aluminum in the molds to fairly quiet steels which require no aluminum in the molds to prevent their rising. Since the steel solidifies in the molds before the reaction between the FeO and carbon is complete, it is obvious that certain steels contain more oxide contents than others even though they be of the same type. This is especially true where the molds are of comparatively small size as happens to be the case in this particular instance.

✦ ✦ ✦

THE variation in structure or normality as indicated by the **McQuaid-Ehn** test has been studied by a number of investigators. **Grossman** (9), has shown that oxygen plays an important part in determining whether or not a steel develops normal or abnormal structures. According to **Bain** (10), in order to secure a normal test structure by the standard **McQuaid-Ehn** test demands the presence, along with carbon and iron, of an element contributing to deep hardening, or at least on reducing the oxygen solubility materially, such as aluminum or silicon. **Bain** further states that in general, steels appear more and more abnormal as the grain size diminishes, a fine grained normal steel requiring the presence of both deep hardening elements and a grain growth inhibitor. A coarse-grained abnormal structure denotes a steel low in the elements contributing to deep hardening and in the elements reducing oxygen solubility.

✦ ✦ ✦

THE results obtained in connection with the non-spotting and spotting galvanizing steels substantiate the results of these previous investigators in that the coarse grained abnormal steels are higher in dissolved oxygen than the finer grained normal steels, due to their particular method of manufacture. The quality or at least the spotting tendency for any particular steel can therefore be predicted from data relating to its manufacture and final analysis. It is realized of course that certain variations can exist within the heat itself due to heterogeneity of such a large batch of material. In good practice however such variations within the heat should be a minimum.

✦ ✦ ✦

## Final Discussion

THE data show conclusively the role of the particular class of steel as influencing the quality of the galvanized surface. The mechanism of spotting has been shown to be that of diffusion of zinc into the steel base, this being supported by data showing increased amounts of zinc in the coatings in addition to spotting, effect of manipulation, and the microstructure of spotted and non-spotted coatings. While undoubtedly pickling accelerates spotting tendencies already inherent to the steel, the role of escaping hydrogen as being a cause for spot formation is untenable in view of facts obtained.

✦ ✦ ✦

THE term quality applied to galvanizing steels is a matter of concern depending upon whether one is interested in the production or consumption of galvanized products. Obviously the type of steel which produces a bright spangled coating with a minimum amount of zinc is highly desirable to the manufacturer since the article possesses sales appeal as well as having been economically produced. On the other hand the consumer is interested in buying protection in the form of a zinc coating but in general is not in a position to make any tests upon the final article. The bright spangled article will gain the favor of the average uninformed buyer over a less bright perhaps spotted article on the grounds that is appears to have more zinc uniformly distributed and in general have the appearance of a high grade product. Data presented herein disprove such assumptions and show that spangled coatings are in most cases thin and that the very presence of the spangle provides weak areas around the boundaries. Furthermore rapid cooling is sometimes resorted to in order to quickly freeze the coating to prevent spotting, a practice which makes the coating brittle and more likely to flake off.

✦ ✦ ✦

IN conclusion, it may be stated that spotting is a property associated with certain classes of steels and consists of the top layers of zinc diffusing into the steel base, leaving a dull gray zinc-iron alloy layer at the surface. Certain other classes of steels retard this diffusion to the extent that thinner coatings result and which have top layers of uncontaminated zinc which forms a characteristic spangle upon freezing. Differences in their **McQuaid-Ehn** carburized structures have resulted in the identifying of these classes of steels as regards their method of manufacture, from which valuable information is at one's command in being able to determine the choice of steel for particular galvanizing purposes.

✦ ✦ ✦

## Bibliography


(1) Hannah, J. D. and Rhead, E. L., "Crystallization Effects on Galvanized Iron", J. Inst. Metals, 30, 79.

(2) Sang, A., "The Zinc Coating of Iron and Steel", Rev. Metal., 9, 1, 78, 160, 275.

(3) Camp, J. M. and Francis, C. B., "The Making, Shaping and Treating of Steel", 4th Ed., pp 903-913, 968-982. Carnegie Steel Co., Pittsburgh.

(4) Poppleton, C. F., "Manufacture of Steel Sheets: What is Necessary in Galvanizing", Iron Age, 101, 740.

(5) White, G. Ax, "A Metallurgical Study of the Steel Base as Related to Galvanizing", Iron Age, 101, 934.

(6) Rosenberg, S., "What is Good Galvanizing?", Chem. Met. Eng., 31, 228, 592.

(7) Singmaster, J. A., "Progress in Commercial Applications of Zinc", Metal Ind. (London), 31, 31.

(8) M. von Schwarz and H. Fromm, "Galvanizing Defects on Steel Sheets because of Defective Base Material", Korrosion & Metallschutz, 11, 241.

(9) Grossman, M. A., "Fifth Campbell Memorial Lecture", Transactions A. S. S. T.

(10) Bain, E. C., "Factors Affecting the Inherent Hardenability of Steel", 20, 385. (Seventh Campbell Memorial Lecture). Transactions, A. S. S. T.

# A. C. Electro-Pickling
# A Better Method of Pickling

By Allan B. Dove

Chemical Engineer, Canada Works,
The Steel Company of Canada, Ltd., Hamilton, Ont., Canada

**This article reviews a year of investigation in the use of Electro-pickling by the Ferro-A. C. Process. The experiments carried out at Canada Works, The Steel Company of Canada, Limited showed greater speed, better surface and lower acid and steel consumption in tests conducted on over 18,000 tons of rods and wire.** ✦ ✦

## Object and Process

IT was our object, at the outset, to develop, with the assistance of the Ferro-Enamel Company, a practice, by which the Ferrolite process could be used to advantage in the pickling of our wire rods at Canada Works. From the outset, we have regarded our work as purely experimental, varying changeable factors from time to time, noting results and comparing with standard pickling processes involving only the use of inorganic pickling acids and standard inhibitors.

✦ ✦ ✦

PAST experimental work had already shown that inhibitors were of very definite value at temperatures not exceeding 190°F.—especially those of the thiourea base type. In the interests of economy, however, we developed the use of pyrolle sludge, obtained in our own Benzol plant, and with excellent results. Both types of inhibitor were pitted against the Ferrolite process during over a year of continual test—a year of trial and error.

✦ ✦ ✦

OUR experiments therefore have been directed to the perfection of a new system of cleaning which would, in speed and economy, form the basis of redesign of our cleaning house as a whole at some future date.

✦ ✦ ✦

## Theory of Electro-Cleaning

ELECTRO-PICKLING processes are not new—indeed there are a great many now upon the market involving the use of direct current. In these "reverse plating" systems, the work is made either the anode or cathode in the circuit in which a current of 50-150 amperes per square foot flows, dependent upon the process used. These processes are described in brief:

A. B. DOVE

Born in Ayr, Scotland. Graduated as Bachelor of Science in Chemical Engineering from Queens University at Kingston, Canada. Associate member of Canadian Institute of Chemistry, member of the Engineering Institute of Canada, holds a commission in Royal Canadian Engineers, author of technical papers on Corrosion, Galvanizing and Pickling. Chemical Engineer, Canada Works, The Steel Company of Canada, Ltd., Hamilton, Ontario, Canada.

## Madsenell Process

THIS process was described in Industrial and Engineering Chemistry 1928 Vol. 20. The work is first pickled in the normal still bath, and then transferred to the Madsenell "degassing" bath where anodic electropickling is employed to remove absorbed gasses and pickling smut. This process, which is carried on at 50 amps./Sq. Ft. with a pressure of 12 volts in an 85% sulphuric acid bath—or even higher concentration—at about 100°F, efficiently prepares the work for further plating by regular methods.

✦ ✦ ✦

## Hanson-Van Winkle Munning Process

IN this process the work is first pickled cathodically in 10-20% acid at 10-150 amperes per sq. ft. Smut is then removed by immersion in a second bath of 40-50% sulphuric in which the work is made the anode. A current density of 100-150 amperes /sq. ft. is used at 50-90°F.

✦ ✦ ✦

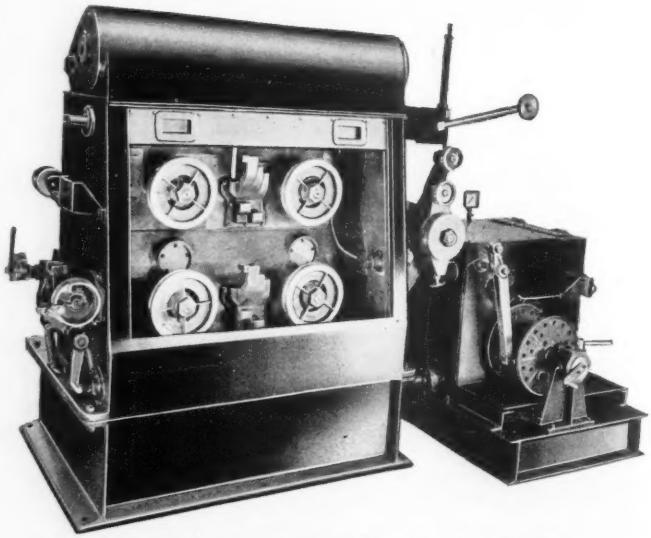
## Bullard-Dunn Descaling Process

THIS process is particularly applicable to small parts. Immediately after cathodically pickling the work as in the above processes, a small amount of tin or lead is plated on to the article inhibiting further action. These two effects are simultaneous, and the pickled product is, on removal from the bath, prepared to resist oxidation by virtue of the electrodeposited coating.

# Visit Our Exhibit At The

## At Atlantic City, N. J.,

## HIGH SPEED WIRE



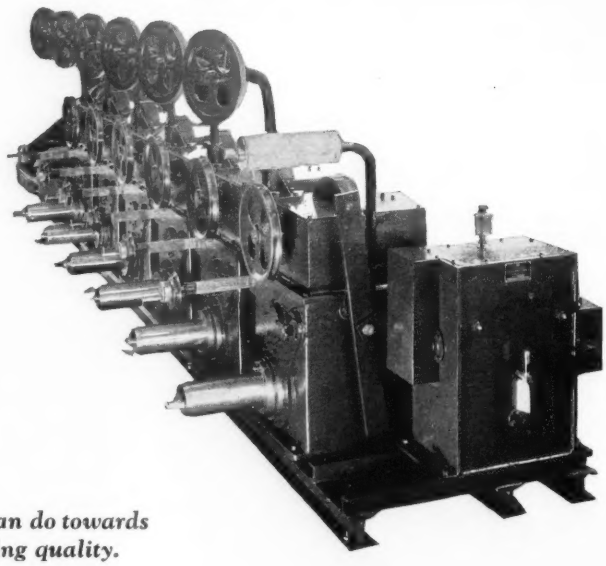
Type C-12 Light Intermediate Wire Drawing Machine

A COMPLETE line, minimum slip, built primarily for high speed drawing — built for long life, efficient operation, economical production and clean and excellently wound quality wire.

✦ ✦ ✦

A machine for every type of non-ferrous wire drawing. Six standard designs. All machines supplied with or without spoolers and with or without coilers.

- Saturating and Finishing Equipment For Weatherproof and Code Wire
- High Speed Insulating Machines For Use With Paper — Cotton — Silk
- Mica Application Units
- Wrapping Machines
- Complete Tinning Equipment
- Taping Heads for Cambric, Paper, Etc.



Six Reel Take Up For Tinning

*Let us show you what our equipment can do towards cutting production cost and improving quality.*
*Specific Information Supplied Upon Request*

EXECUTIVE AND SALES OFFICE
420 LEXINGTON AVE., NEW YORK, N. Y.

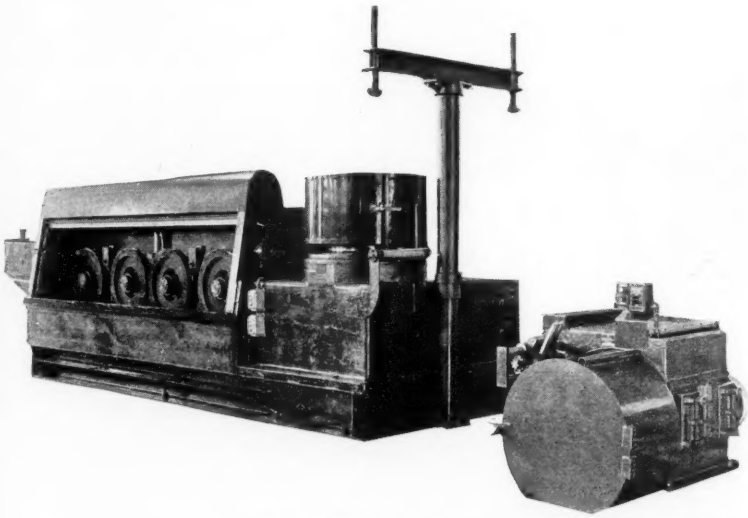
# ELEVATOR SUPPL

# National Metal Congress

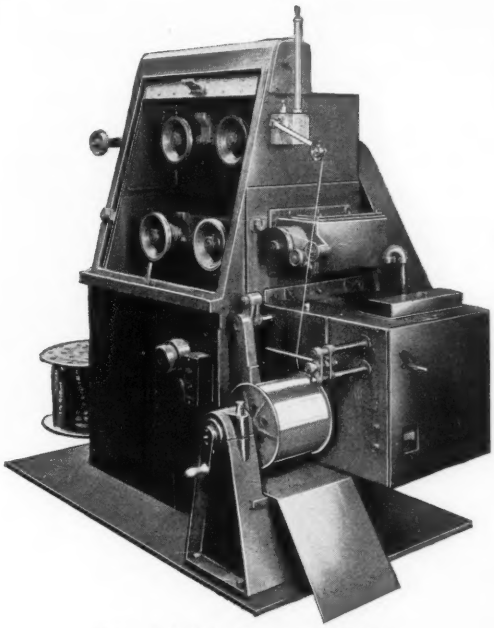
## October 18 to 23, Inclusive

ES

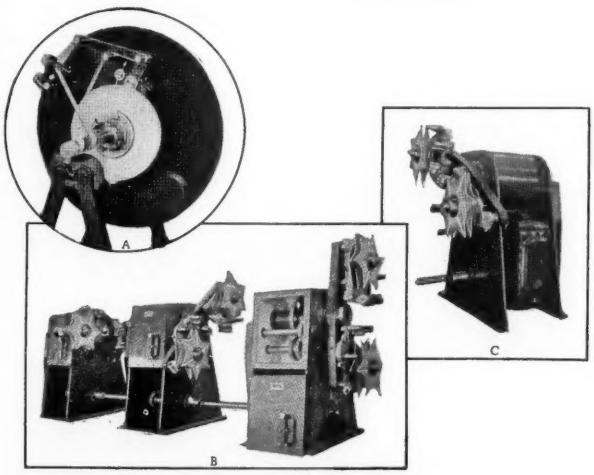
## DRAWING EQUIPMENT



Type "F" Heavy Duty Rod Breakdown Machine



Type B Wire Drawing Machine




Taping Heads for Cambric, Paper, Etc.

- Six Spooler Take-ups
- Capstan Type Take-ups
- Capstan Type Double Coilers
- Take-ups — Spoolers — Coilers
- Pay Off Stands for Large Reels

***Let us us show you what our equipment can do towards cutting production cost and improving quality. Specific Information Supplied Upon Request***

# IES COMPANY, Inc.

WORKS
RAHWAY, N. J.

ALL the processes described above have in common, the fact that the direct current is applied to the article cathodically to remove the fire scale. These processes are all directed toward the pickling of small parts, but can be developed to suit strand pickling. This latter method would be too expensive for normal rod pickling unless in preparation for a strand operation such as hot or electro-galvanizing.

✦ ✦ ✦

## The Ferrolite Process

THE theory of the Ferro process is somewhat obscure. It is not one simple reaction, but rather a series of organic and inorganic complexes, the most important of which are shown as Table A.

✦ ✦ ✦

IN the first group of five equations we have all the changes taking place in an ordinary still pickling bath. Number (5) demonstrates the ionization of sulphuric acid which is reversible, while numbers (1), (2) and (4) represent the solution of the three known iron oxides existant in mill scale. In all these actions we find the production of ferrous and ferric sulphates along with water. When the scale is removed, however, ferrous sulphate and hydrogen are produced according to equation (3); this action is to be avoided as far as possible.

✦ ✦ ✦

ACTIONS (6), (7) and (8) are the assumed inorganic-organic reactions by which the gluconic acid of Ferrolite does its work. In action (6) ferrous oxide and gluconic acid produce ferrous gluconate which is in turn reacted upon by ferric sulphate formed in (1) and (2) to produce, with water, ferri-gluconic acid and free hydrogen and sulphate ions.

TABLE A

| | | |
|---|---|---|
| (1) | $Fe_3O_4$ + $4H_2SO_4$ → | $Fe_2(SO_4)_3$ + $FeSO_4$ + $H_2O$ |
| | Black Scale Sulph. Acid. | Ferric Sulphate Ferrous Sulph. Water |
| (2) | $Fe_2O_3$ + $3H_2SO_4$ → | $Fe_2(SO_4)_3$ + $3H_2O$ |
| | Red Scale | |
| (3) | Fe + $H_2SO_4$ → | $FeSO_4$ + $H_2$ |
| | Iron | |
| (4) | FeO + $H_2SO_4$ → | $FeSO_4$ + $H_2O$ |
| | Ferrous Oxide | |
| (5) | $H_2SO_4 \rightleftarrows 2H^+ + SO_4^=$ | |
| | Ionic Hydrogen | Sulphate Ion |
| (6) | FeO + $2C_6H_{12}O_7$ → | $Fe(C_6H_{11}O_7)_2$ + $H_2O$ |
| | Gluconic Acid | Ferrous Gluconate |
| (7) | $Fe_2(SO_4)_3$ + $4H_2O$ + Fe $(C_6H_{11}O_7)$ → | $FeSO_4$ + 2Fe $C_6H_{13}O_9$ + $2H_2SO_4$ |
| | Ferric Sulphate Ferrous Gluconate | Ferrous Sulphate Ferri-Gluconic Acid |
| (8) | $FeSO_4$ + $2C_6H_{12}O_7$ → | $Fe(C_6H_{11}O_7)_2$ + $H_2SO_4$ |
| | | Ferrous Gluconate |

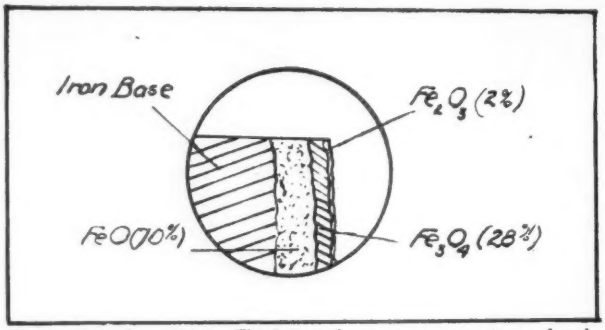



Fig. 1. Scale Composition. The figures show average percentages of each scale element.

✦ ✦ ✦ ✦ ✦

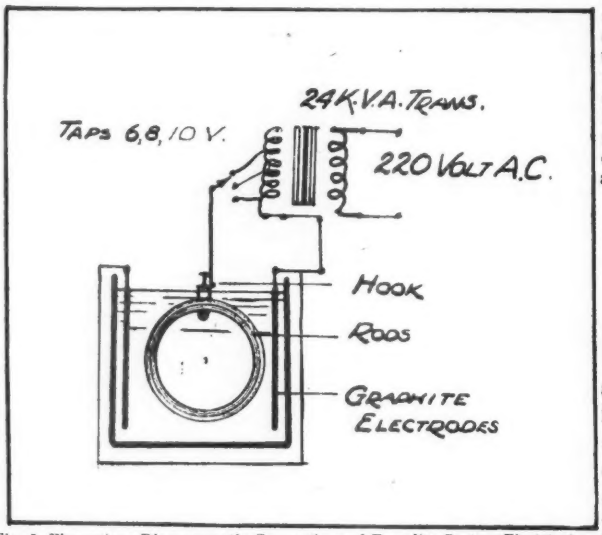



Fig. 2. Elementary Diagrammatic Connections of Ferrolite System First test.

IT is our opinion that action No. (1) is slight—(2) occurs only when red oxide $Fe_2O_3$ is present on the surface—and that (4), the action of acid on Ferrous oxide, FeO, proceeds with great speed dropping off black scale particles ($Fe_3O_4$) which may often be seen floating on the bath surface.

IN order to catalyse these reactions 60 cycle A. C. current is applied to the system. We should now theoretically have results as follows:—

**1. Lower acid concentrates due to the reproduction of sulphuric acid in actions (7) and (8).**

**2. Lower steam consumption in heating due to electrolytic energy supplied to the bath.**

**3. Rapid cleaning due to catalysis by applied electrical energy. During the cathodic half of the A. C. wave, organic action between gluconic acid, ferrous gluconate and the iron oxides are stimulated; during the anodic half of the wave the attack on the ferric oxides proceeds by deposition of the negative sulphate ion ($SO_4$).**

✦ ✦ ✦

## Actual Operation of the Ferrolite System

FOLLOWING the primary investigations of the system in laboratory tests, it was decided to install an experimental equipment capable of pickling one load at a time. In this first experimental equipment—an oval wooden tub, capacity 1100 Imp. gallons — six dense graphite electrodes were installed on each side of the load position.

✦ ✦ ✦

WHILE the Ferrolite system is primarily designed for use with 60 cycle current, power complications in the Niagara area made it imperative that we use 25

cycle current. This increased the core weight of our transformer and caused some misgiving regarding what our final results might be.

✦ ✦ ✦

OUR original hook-up was as shown in Fig. 2. We incorporated in the system, however, current safety switching devices, meters, and control panel as shown in Fig. 3. Analysis of acid concentration, ferrous iron and readings of current and time were checked before every load was placed in the tub. Two adjacent tubs in the circle were kept as checks and every load under test in the three tubs was numbered and followed through its operations.

✦ ✦ ✦

BY the time 1100 loads had been cleaned in the electrical equipment all the necessary current values and additions had been fixed. By a method of trial and error the following values were determined as correct for this type of tub:—

**Acid—2.5—3.0% by vol.**
**Iron Max.—12.0% Ferrous Iron by $KMnO_4$**
**Temperature—170° @ 6 volts up to 5% Ferrous iron**
**175° @ 8 volts 5% to 10% Ferrous iron**
**180° @ 10 volts 10% to runout**
**Ferro addition—2½% by weight of acid addition.**
**Acid at runout—less than 1% by vol.**
**Current value—average 1200 amps. per load.**

✦ ✦ ✦

IT should be understood that as the iron value builds up, more potential is required to maintain current values. The final average cost results after two months of steady operation in comparison with sludge and thiourea base inhibitors is shown in Table 1.

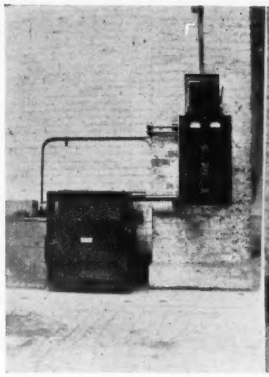
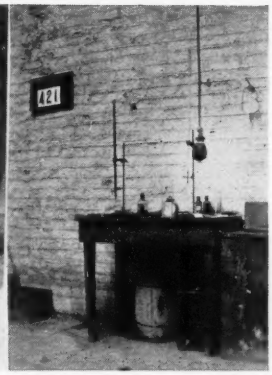


Fig. 3. Control Panel




✦ Fig. 4. Analysis Bench. ✦

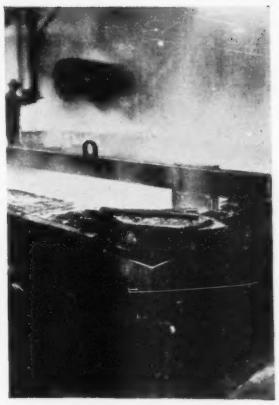


Fig. 4A. A-C Tank in Operation.

IT is notable that no black scum, indicating concentration areas, had shown up on the rod loads in spite of the fact that the end electrodes at each side of the tank were closer than the center ones.

✦ ✦ ✦

GRAPHIC results (Fig. 5) showed the electrolytic system to have an advantage in period of activity over all other methods used, permitting, without excessive iron loss, the attainment of a new high iron value before dumping became necessary. This factor, combined with the increased speed and acid savings (See Table No. 1) indicated the electrical system to be of decided advantage, and worthy of further experiment.

✦ ✦ ✦

## Double-Pin Tub Experiment

OUR work with the single pin experiment had indicated that we had plenty of current to spare in our original transforming equipment, providing that we did not demand too great a throwing distance for the comparatively low voltage values used.

WORKING hand-in-hand with the Ferro Enamel Company we redesigned the equipment to suit double yokes. A new tub was built of Douglas-fir, rectangular in section, with an operating capacity of 2245 Imperial gallons. Seven electrodes were installed at each end, a central partition was built to carry seven additional electrodes and two pads were now provided for connection to the rod carriers. To be sure, wooden construction was not the best possible—it could have been more suitably built up using a brick and rubber lined metal tub. It was discovered that we had a two-volt drop through the wooden equipment after a few months of operation.

✦ ✦ ✦

## Operation of Equipment

FROM commencement it was found that the double-pin tank gave even better results than had been expected. A slight change was made in the operating temperature in order to obtain best results.

TABLE NO. 1—FINAL RESULTS OF SINGLE OVAL TUB TESTS

| FACTOR | Tub No. 1 Electrolytic Acid 2.5-3% Vol.) | Tub No. 2 Regular Acid 1½-2½% (Vol.) | Tub No. 3 Regular Acid 2½-3% (Vol.) |
|---|---|---|---|
| Time/Ton | 24.20 mins. | 39.1 mins. | 42.45 mins. |
| Acid/Ton | 31.33 # | 39.7 # | 44.36 # |
| Power/Ton | 4.35 K. W. H. | — | — |
| Ferro/Ton | .695 # | — | — |
| Inhibitor/Ton (Est'd.) | | .028 gals. Sludge | .032 gals. Sludge |
| Steam/day | 1670 # | 8352 # | 8352 # |
| Total Cost/Ton | $0.415 | $0.524 | $0.571 |

THE standardized operating conditions of this equipment are as follows:—

**Acid—2.4-3.0%**
**Iron max. 14.0% (Acid additions cease at 12.5% ferrous iron)**
**Temperature—175° at 6 volts up to 5% ferrous iron**
**180° at 8 volts from 5-10% ferrous iron**
**185° at 10 volts from 10-14% ferrous iron**
**Ferro addition—2% by weight of acid addition**
**Current value—Approx. 750 amps. per load.**

✦ ✦ ✦

THE temperature, it will be noted, is varied with the operating voltage; the voltage must necessarily be varied, as with the oval tub experiment, in order to overcome the increasing resistance of the bath as the iron value increases.

✦ ✦ ✦

## Results of Tests

DURING the period of test, from which results used in this paper were taken, some 16,000 tons or about 13,000 loads have been pickled electrically with excellent results in all departments. Every load under test—in any type operation—was numbered throughout all wire mill operations whether intended for galvanizing or drawing. Loads defective in any respect were reported by number. In not one case has a load cleaned in the electrical equipment been reported for poor adherence in galvanizing, black scum interference due to over-pickling, or brittleness due to hydrogenation. During the early weeks of the experimental operations, there were, admittedly, a few scaley loads, but these were soon eliminated by practice correction.

✦ ✦ ✦

THE Grades pickled ranged through all carbon steels from 0.04% to 0.92%, and all sizes from 14 ge. up to 0.982". The stocks pickled consisted of drawn wire, patented wire and rods, hot rolled rods, annealed and normalized wire. Much of the latter class was very badly burned, and "pickle-pitting"—quite unavoidable under such conditions—resulted.

✦ ✦ ✦

THE average results of the various tests are shown in tabular and graphic form in Table 2 and Figure 6. The lists compared here are:—

**A—7% by vol. inhibited sulphuric**
**B—3% by vol. inhibited sulphuric**
**C—1½% by vol. inhibited sulphuric**
**D—7% by vol. Sludge inhibited sulphuric**
**E—3% by vol. Sludge inhibited sulphuric**
**F—1½% by vol. Sludge inhibited sulphuric**
**G—2½-3% electrical Ferrolyte Process.**

✦ ✦ ✦

THE results shown in Table 2 are conclusions drawn from summaries of 300-16000 tons test lots, and should not be confused with laboratory type tests.

✦ ✦ ✦

FROM the graphic and tabular analyses of the operations of the various tubs we are brought to the conclusion that the Electrolytic Ferro process is preferable because of:—

**1. Relatively low iron loss per ton cleaned.**

**2. Sustained Tank life, permitting longer runs before dumping is necessary. Over week-ends oxidation of ferrous sulphate to ferric sulphate causes a drop in Ferrous iron of 1-2%, and for this reason it is of advantage to allow an Electrolytic tub to stand during shut-down periods. It should be emphasized that FERROUS iron, NOT FERRIC iron, affects the working life of the tank.**

**3. Rapid cleaning over long periods.**

**4. A distinct saving in steam used for heating. Our experimental evidence showed a saving of 50-75% was possible in steam added to the bath for the purpose of maintaining temperature. There was almost enough heat produced by the electrical action to hold the bath at a temperature of 175-185°F. during the complete cycle of operations.**

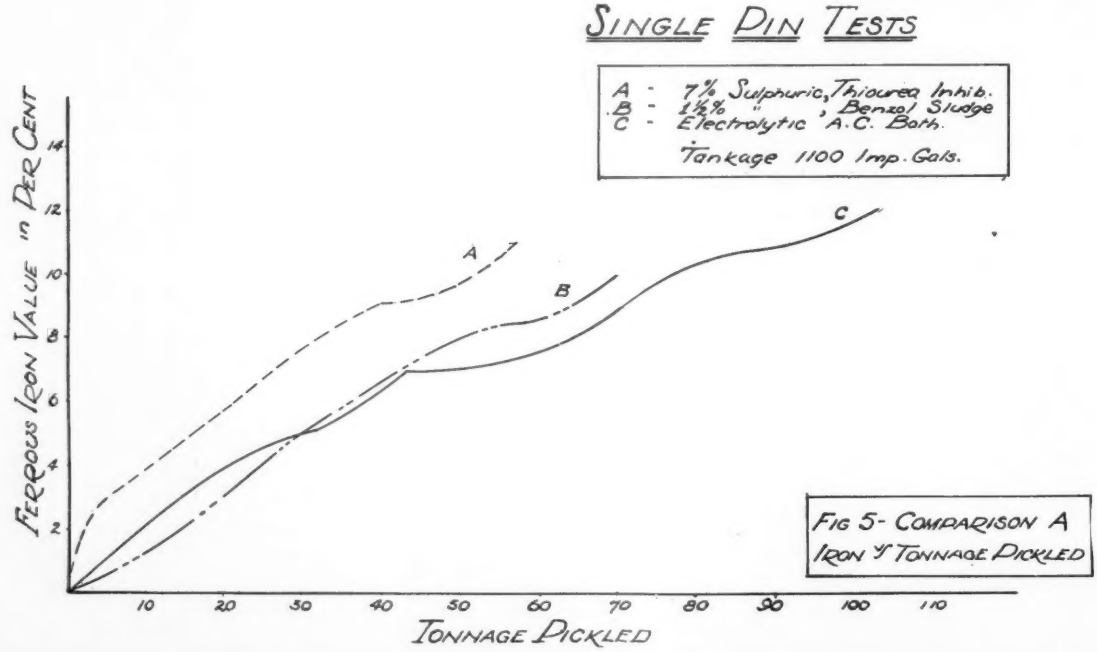
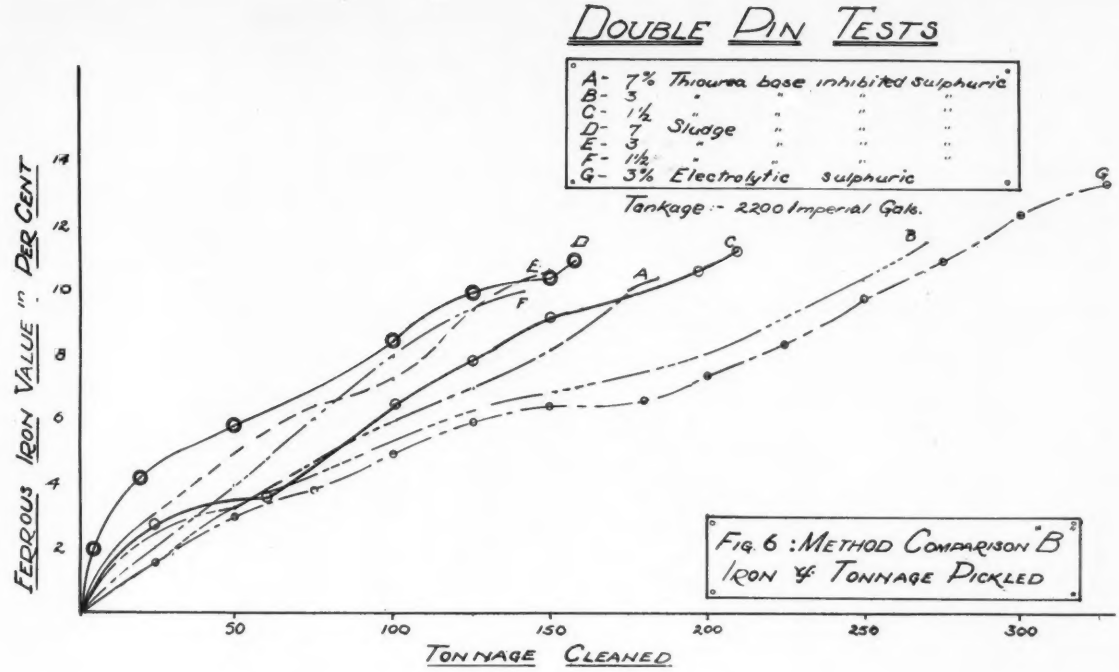



FIG 5- COMPARISON A IRON V. TONNAGE PICKLED


DOUBLE PIN TESTS
A- 7% Thiourea base inhibited Sulphuric
B- 3 " " " "
C- 1½ " " " "
D- 7 Sludge " " "
E- 3 " " " "
F- 1½ " " " "
G- 3% Electrolytic Sulphuric
Tankage :- 2200 Imperial Gals.
FERROUS IRON VALUE IN PER CENT
TONNAGE CLEANED
FIG. 6 : METHOD COMPARISON "B"
IRON % TONNAGE PICKLED

## Quality of Work

IN Canada Works, as in any other Wire Mill, clean rods are the first requisite to good drawing. Die troubles, poor adherence in galvanizing, acid brittleness or poor appearance of any load of wire was at once traced back to the cleaning operations by means of identification tags which, by number, indicated the process used. In none of the 16,000 tons cleaned electrically has there been evidence of hydrogen embrittlement, poor galvanizing adherence, or, in the case of spring wire or rods, pickling-smut due to overpickling.

✦ ✦ ✦

THERE is a marked improvement in the finish of all rods pickled electrically (See Fig. 7), and it was found that, in spite of the thiourea base inhibitor, electrically pickled work could be readily copper coated for drawing purposes. This is in direct contravention to the general practice; normally the presence of inhibitors in the pickling solution will prevent uniform copper coating of steel wire or rods.

✦ ✦ ✦

## Summary


**1. The results found in the use of the electrical process are obtained by virtue of organic and inorganic chemical reactions catalysed by 25 cycle alternating current.**

**2. The organic reactions are those involving gluconic acid, iron oxides, and iron sulphates. By these actions ferrous iron is removed from the pickling solution in effect oxidation of ferrous to ferric iron is assisted, and sulphuric acid is regenerated. The noticeable result is that of longer active tub life, low acid consumption, and rapid pickling action. The regeneration action itself is negligible in effect.**

**3. Graphic and tabular results illustrate that, in speed, pickling efficiency, low iron losses, and cost, the electrolytic A. C. method is of definite advantage. The greater portion of the cost saving is due in the main to the lesser amounts of live steam required for heating. If steam costs be disregarded, we feel that the Electrolytic operation can be still used on a par with other normal type of pickling; at identical cost, therefore**


TABLE NO. 2

The tub characteristics compared in Table No. 2 are shown on a basis of a 2200 (Imperial) gallon tank.

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| Acid #/Ton | 40.0 | 37.0 | 30.0 | 49.3 | 37.4 | 40.2 | 29.35 |
| Time mins./Ton | 25.3 | 32.5 | 35.0 | 22.9 | 33.6 | 39.6 | 23.5 |
| Power K.W.H./Ton | — | — | — | — | — | — | 3.22 |
| Ferro #/Ton | — | — | — | — | — | — | .62# |
| Inhib. Pints/Ton | .138 | .163 | .133 | .209 | .190 | .286 | — |
| Tonnage | 184 | 270 | 208 | 144.0 | 196 | 144.0 | 328.4 |
| Ferrous Iron at Dump Point | 10.5% | 10.0 | 11.0 | 10.5 | 9.9% | 10.0 | 13.5 |

there would still be the advantages of low iron loss, high speed pickling, and excellent quality of surface.

4. We feel that the results quoted here (Table No. 2 col. G) can be greatly improved upon by the use of rubber and brick lined steel tubs. This type of lining would reduce current leakages and acid consumption per ton, and thereby increase the efficiency of the operation as a whole.

5. We recommend that only monel metal equipment be inserted into the solution in the form of carrying hooks and steam lines. Other stainless alloys, copper, brass and lead proved of little value in our tests. Copper shows a tendency to plate onto the work during pickling.

✦ ✦ ✦

REFERENCES.

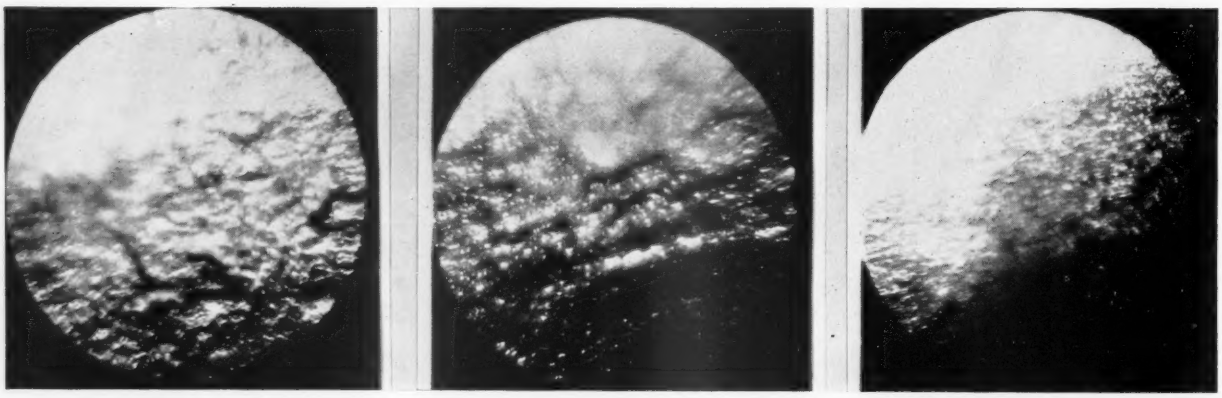
(1) A. S. M. Handbook—1936

(2) Pfeil: Proceedings of Iron and Steel Inst. Vol. CXXIII

Dove: Pickling of Iron and Steel Can'n. Chemistry and Metallurgy: Sept. 1933

✦ ✦ ✦

THE writer wishes to express, to the Steel Company of Canada Limited, his appreciation for permission to publish this article.



7% Inhibited Sulphuric
180°F. Low Carbon
Basic Steel

3% Inhibited Sulphuric
180°F. Low Carbon
Basic Steel

3% Electrolytic Cleaned
180°F. Low Carbon
Basic Steel

Fig. 7. Comparison of Surface Finishes by Three Processes on the Same Heat of Low Carbon Steel by Reflected Light. (50X approx.) ✦ ✦

ANNEALING REELS SPOOLS PROCESS REELS

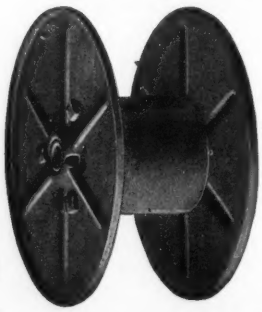
THE AMERICAN PULLEY COMPANY
4200 WISSAHICKON AVENUE
PHILADELPHIA

Steel Reels
All Welded

Let Us Help You With Your Reel
and Spool Problems

✦ ✦ ✦

Spools to the Trade
For All Purposes



We have the necessary equipment to produce all types of reels and spools skillfully, quickly and economically—let us have your specifications or send them to our special representative, **Walter A. Richards, 20 North Wacker Drive, Chicago, Illinois.**

STRANDING REELS BRAIDER REELS VULCANIZING REELS

# MORGAN
## Wire Mill Equipment

•

Bull Blocks, Horizontal or Vertical
*Direct Motor Connected*

Rod Frames with Carroll
Friction Blocks

Galvanizing and Patenting Equipment

Morgan-Connor Wire Machines

Pointers Trucks Bakers

Accessory Equipment

# Lime In The Wire Industry

By D. E. Washburn,

Chief Chemist, American Lime & Stone Co., Bellefonte, Penna.

This paper points out the factors which affect the physical properties of lime used in wire drawing, and is presented with the hope of familiarizing the industry with the study given its problem by the lime manufacturer. ✦ ✦ ✦ ✦

ALTHOUGH some hydrated lime is employed in wire drawing, the major tonnage by far consists of high calcium quicklime, which, of course, is the product resulting from the approximately complete calcination of high calcium limestone, involving principally the dissociation of calcium carbonate into calcium oxide and carbon dioxide. Temperatures ranging from 2000°F. to 2500°F. are required to economically manufacture a commercial product.

✦ ✦ ✦

GEOLOGICALLY, it would be possible to name some forty different varieties of limestone, distinguished from one another by their chemical and physical compositions. There is probably not one state in our union which cannot boast a deposit of at least one variety of limestone. Here are two varieties of limestone selected principally to exemplify extreme color variations. The darker variety is a Carboniferous Limestone, and is a comparatively pure stone found in the carboniferous systems, and constituting a large proportion of many mountain ranges. The almost pure white variety seems to be something in the nature of white marble. In spite of their extreme color variation, they both burn to practically a pure white product. Out of all the many deposits of the various types of high calcium limestones, there are relatively only a small number adaptable to the production of lime for the various industries, of which the wire drawing industry taken as a whole employs a considerable tonnage. Either unfavorable chemical or physical properties or a combination of both disqualify many limestones for the manufacture of quicklime for use in industry.

✦ ✦ ✦

D. E. WASHBURN

Born White Haven, Pa., March 3, 1883. Graduated from White Haven High School in 1901. Studied chemistry at the Pennsylvania State College and graduated, receiving degree B.S., in 1906. Accepted position as open hearth chemist with American Steel Foundries Company at East St. Louis, Mo. In 1909 became assistant chief chemist with same company at Granite City, Ill. In 1912 took charge of the laboratories of the Bellefonte Iron Company and Nittany Iron Company, Bellefonte, Pa. Became chief chemist of the American Lime and Stone Company in 1921, until Warner Company, Philadelphia, assumed control in 1922, since which time he has been chief chemist and technical sales representative of the Bellefonte Division of the Warner Company.

IN the manufacture of lime, two main types of kilns are employed, namely the shaft kiln and the rotary kiln types.

✦ ✦ ✦

A SHAFT kiln is essentially a vertical, metal cylinder lined with refractories, with a storage hopper at the top, principally as a stone storage. Many shaft kilns are fired from dutch ovens, which open into the shaft, but only the products of combustion are supposed to pass through the eye of the oven into the shaft. Shaft kilns can be designed for the use of coal, producer gas, natural gas and fuel oil. Limestone ranging in sizes from 5 to 12 inches are charged in the top of the kiln. About every six hours the calcined product is drawn off at the bottom, and the operation so manipulated that fresh stone moves down into the hot zone of the kiln to be further calcined. This is only a very brief and incomplete description of shaft kiln practice, and is given principally to stress the point that on account of the very nature of the operations, the calcined product has of necessity been subjected to an excessive amount of heat as compared with a rotary kiln product to be described later.

✦ ✦ ✦

ROTARY kilns, like shaft kilns, are also essentially metallic cylinders, lined with refractories. They are many times the length of shaft kilns, and they are set up in an almost horizontal position with an inclination of ½ to ⅜ inches per foot. Until just recently, their maximum length has been 175 feet, with a diameter of 9 feet. Lately,

however, several kilns 400 feet long have been set up. It remains to be proven if this additional length is of any advantage. The same fuels employed in shaft kilns can be used with rotary kilns. Coal can be employed either in a gas producer, or more directly in the form of powdered coal. Incidentally, the long kilns mentioned employ powderd coal.

✦ ✦ ✦

IN rotary kiln practice the limestone is crushed down to a maximum size of about 1½ inches and classified into separate classifications, each of which is separately fed into the kiln at a prescribed rate. A wide range of stone sizes are not adaptable to uniform calcination. Stone sized so that the diameters of the largest pieces are twice that of the smallest, provides the proper range for uniform calcination. Properly sized stone moves down the inclination of the kiln to encounter a counter flow of heat, and discharges through the hot end, where it is cooled, and can be further subjected to a process of selection or processing prior to shipment for various chemical and industrial uses, not the least one of which is wire drawing.

✦ ✦ ✦

ON account of the relatively small stone sizes employed as compared with shaft kiln operations, the time required to completely convert limestone into lime is greatly reduced. A rotary kiln product is in a calcining temperature of about one hour as compared to at least four hours or more for shaft kiln production. Plant control is readily adaptable to rotary kiln production, whereas it is to a large degree impossible with shaft kiln production. There is no question that particularly the physical properties of the lime, and to some extent, its chemical properties, are influenced by the length of time it has been subjected to high temperatures.

✦ ✦ ✦

MENTION has already been made of the use of powdered coal in rotary kiln practice. While powdered fuel travels through a combustion chamber, yet a goodly portion comes in contact with the hot lime, either partially burned or entirely so in the form of coal ash. It is only reasonable to assume that the more directly the heat of the fuel can be applied to the burning of lime, the more economical the process will be from the standpoint of fuel cost. To what extent, however, that ash contamination and discoloration through fusion will affect quality is yet to be determined. At the same time, it is also only reasonable to expect improvements and refinements which may put the use of powdered coal on a par with gas.

✦ ✦ ✦

ALL the discussion up to this point has been deemed advisable in order to furnish the background which to a great extent influences the physical properties of lime for wire drawing.

✦ ✦ ✦

## Physical Properties of Lime for Wire Drawing

IN the January number of the magazine Wire and Wire Products, there was a summary of information compiled by the Waterbury-Farrel Foundry and Machine Company on "American Methods Used in the Manufacture of Rod and Wire for Cold Heading, etc." To one not particularly up on details of the industry, that article constitutes a wealth of information. The author's quotation on one opinion involving the requirement of a lime bears repeating—

**"In the matter of lime, physical as well as chemical character is significant and while some companies set up chemical limits nobody feels entirely sure that they are adequate. Limes outside the generally recognized limits sometimes do very well, and vice versa.**

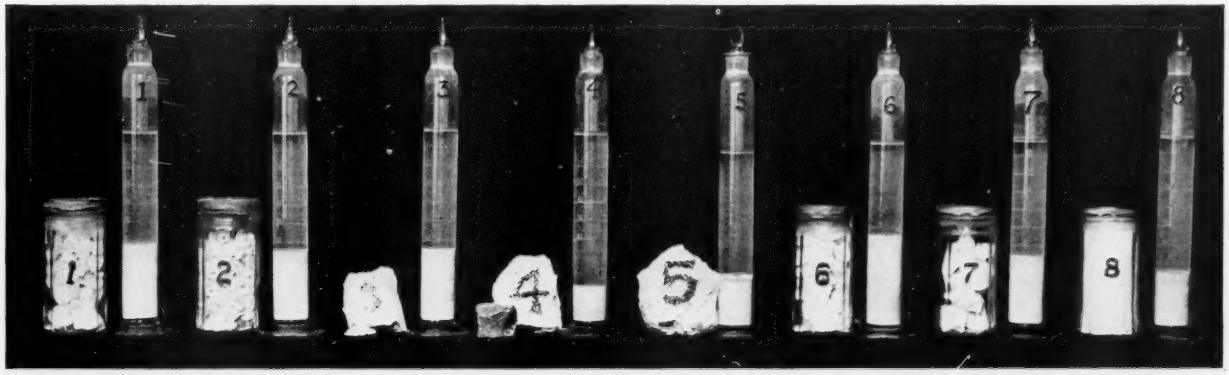
**"A 95% Chemical Pure Calcium Hydroxide seems in every case to give an excellent coating. Magnesia on the other hand causes the lime to lack adherence. Silica is very harmful, but in certain forms a considerable amount of it may be tolerated; that is, as Calcium Silicate rather than Silicon Dioxide. As only about two pounds of lime is consumed per ton of rod, it pays to take no chances. It would seem better, therefore, to make absolutely certain that a good source of lime be used, and too much purity certainly would cause no harm."**

✦ ✦ ✦

THE first paragraph of this quotation is particularly pertinent to the subject at hand, namely that **physical** character is significant. In order to illustrate that point I have selected a number of lime samples with the hope of demonstrating some of the factors which influence the physical characteristics of lime. There are here seven samples of quicklime and one sample of hydrated lime. Along side each sample of lime there is a settling-tube containing a milk of lime made from the corresponding sample of lime.

✦ ✦ ✦

SAMPLES 1 and 2 are rotary kiln products made with the use of powdered coal and burned from the same limestone. Samples 3, 4,



and 5 are shaft kiln products burned from another type of limestone, and representing different degrees of burning. Sample No. 3 is a mild burned product, No. 4 is an excessively hard burned, and No. 5 is normally hard burned. Samples 6 and 7 are rotary kiln products burned from the same ledge of limestone employed for 3, 4 and 5. Sample No. 6, however, was burned with producer gas, while No. 7 was burned with powdered coal in a 400 ft. rotary. Sample No. 8, of course, is hydrated lime, and represents a commercial product made from lime corresponding to No. 6. All the samples except No. 8 have approximately the same chemical analysis in spite of their varying physical appearances, and it may be interesting to learn that samples 1 and 2 have a slight edge on the other quicklimes in the matter of chemical analysis. All samples were selected some weeks ago, but have been kept in sealed containers in order to preserve their original slaking characteristics, which we are now ready to demonstrate.

✦ ✦ ✦

BY adding a little water to a few pieces from each sample, it is observed that at first there is no apparent action in samples 1, 2 and 3, but in less than a minute action starts and the limes break down. All three can be classed as comparatively quick slaking limes. Samples 1 and 2 because of their appearance would no doubt be disqualified for wire drawing, although No. 1 might make the grade. Their very appearance would seem to indicate that they ought to be slow in slaking and yet they are really fast in slaking and on a par with No. 3, which is an exceptionally soft burned lime for a shaft kiln product. There is this to note, however—samples 1 and 2 are very porous as compared with No. 3, which allows a ready penetration of water to the inside of the lumps to come in contact with the softer burned portions, and bring about an initial quick slaking action. The porosity apparently, therefore, is a compensating factor in helping out an otherwise overburned condition. Sample No. 3 on the other hand is a comparatively dense material and gets its initial fast slaking from the fact that it has been only mildly calcined, although completely so. Sample No. 4 is a dense and excessively hard burned shaft kiln product. Its slaking is likewise extremely retarded. Sample No. 5 is also a hard burned shaft kiln product, but not nearly as hard burned as No. 4, so that while its slaking action is very slow, it is just about the rate expected from a very hard burned lime. Sample No. 6 represents a producer-gas lime made in a 175 ft. rotary, from the same ledge stone employed for samples Nos. 3 to 7, inclusive. In its complete calcination it was subjected to the minimum necessary time-temperature. On the addition of water its slaking action is exceptionally violent, which can be attributed to the fact that a proper heat control was exercised in its manufacture to insure a mild burning and the prevention of serious densification through over burning. Sample No. 7 is very fast in slaking, although it lacks the extreme violence of No. 6.

✦ ✦ ✦

THESE slaking characteristics are presented to your attention in order to illustrate to what degree they reflect the settling rates and final volumes of solids in the milks of limes produced from the various lime samples.

✦ ✦ ✦

IN determining settling rates and final volumes of solids, the following procedure was employed—Samples of quicklime were crushed to an 8 mesh product and 7½ grams were slaked with just enough water to form a putty about the consistency of butter. The water used was of room temperature, except in the case of sample No. 4 where warm water was employed. You have already noted how slow sample No. 4 slaked, so that it was really necessary to help it along with some additional heat in order to give it a fair chance. After a period of one hour, the putties were made into milks of lime, transferred to settling tubes before you, diluted with water to 100 cc each, thoroughly shaken, and the amount of settling noted at five minute intervals over a period of fifty minutes, and at the end of twenty-four hours when also the final volume of solids were recorded. In the case of sample No. 8, which is a hydrated lime, instead of 7½ grams, 10 grams were made into a milk of lime for a settling test, in order to have the CaO content approximately equal to that of the quicklimes. Table A constitutes a record of the tests.

✦ ✦ ✦

YOUR attention is first drawn to the recorded final volumes of solids as being of utmost significance. Inasmuch as lime coatings on rods and wires are made up of these solids, it is only reasonable to conclude that generally the lime which will produce the greatest volume of yield of these solids per unit weight of lime employed must

TABLE A
SETTLING RATES AND FINAL VOLUME OF SOLIDS

| Time of Settling | Amount of Settling | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 | No. 6 | No. 7 | No. 8 |
| | cc | cc | cc | cc | cc | cc | cc | cc |
| 5 Minutes | 2. | 2.5 | 2. | 48. | 8.5 | 1.5 | 4.5 | 7. |
| 10 Minutes | 5. | 5.5 | 4. | 78. | 18.5 | 3.0 | 10.0 | 13. |
| 15 Minutes | 8. | 9.0 | 6. | 79. | 25.0 | 4.0 | 16.0 | 17. |
| 20 Minutes | 11. | 14.0 | 10. | 79. | 34.0 | 4.5 | 18.8 | 23. |
| 25 Minutes | 14.5 | 17.5 | 14. | 79.5 | 43.0 | 8.0 | 22.0 | 29. |
| 30 Minutes | 17.0 | 22.0 | 17. | 79.5 | 53.0 | 10.0 | 27.0 | 35. |
| 35 Minutes | 19.5 | 25.0 | 19. | 79.5 | 54.0 | 11.0 | 29.0 | 37. |
| 40 Minutes | 22.0 | 28.0 | 21. | 79.5 | 55.0 | 12.0 | 32.0 | 40. |
| 45 Minutes | 24.0 | 30.0 | 23.5 | 79.5 | 56.0 | 14.0 | 34.0 | 42.5 |
| 50 Minutes | 26.0 | 33.0 | 26. | 79.5 | 57.0 | 16.0 | 36.0 | 45. |
| 24 Hours | 60.0 | 63.0 | 63. | 83.0 | 73.0 | 50.0 | 64.0 | 63. |
| Final Volume of Solids | 40.0 | 37.0 | 37. | 17.0 | 27. | 50.0 | 36.0 | 27. |

certainly be the most economical. As a rule, high calcium quicklimes will produce anywhere from 70 cu. ft. to 110 cu. ft. of lime putty per ton of quicklime employed. High calcium hydrated lime will produce from 40 to 50 cu. ft. of putty per ton. Sample No. 6 represents a quicklime that produces approximately 105 cu. ft. of putty per ton. As the final volume of solids in the above table are really measures of putty yields, it is a simple problem in arithmetic to calculate putty yields per ton for the various limes by comparison with No. 6 as a standard. For example, the putty yield of lime No. 1 would be—

$$\frac{40}{50} \times 105 \text{ cu. ft.} = 84 \text{ cu. ft. per ton}$$

✦ ✦ ✦

LIMES 4 and 5 would produce abnormally low putty yields. They are extremes, however, and were specially selected to demonstrate the effects of abnormal hard burning. No wire drawing account would ever receive an entire shipment of such material, but it is quite possible to receive different degrees of burning that will reflect various amounts of lime coating.

✦ ✦ ✦

A STUDY of the settling rates as recorded are also indicative of how far a lime will reach in wire drawing. Settling rates on limes 1, 2 and 3 accord fairly well with their final volumes of solids. Limes 4 and 5 have exceptionally fast settling rates and would produce low putty yields. Lime No. 6 has an exceptionally slow settling rate with the highest putty yield. Lime No.7 appears to be somewhat inconsistent. Its initial settling rate is rather fast as compared with 2 and 3, and yet its final volume of solids is practically the same. Its initial settling rate should be somewhat slower to be in accord with its final volume of solids. The lime if you will recall is a rotary kiln, powdered coal product, produced in a superlength kiln. It has just recently come on the market and in a sense represents a plant experiment in the economics of mass lime production. It is quite possible that further improvements in plant technique may eventually put it on a par with lime No. 6.

✦ ✦ ✦

SETTLING rates and final volume of solids on sample No. 8 (hydrated lime) illustrates only too clearly the economic value of quicklime over hydrated lime in the wire drawing industry. Notwithstanding the fact that sample No. 8 is a hydrated lime representative of the commercial product produced from quicklime No. 6, yet its putty yield is only approximately one-half as great. This is accounted for by the fact that the commercial production of all hydrated limes involves a dry slaking process that very much affects the physical properties of the resultant hydrate.

✦ ✦ ✦

IN summary, it might be advisable to state that this discussion was prepared principally to point out a few of the factors which affect the physical properties of lime used in wire drawing. It has dealt mainly with physical properties and for that reason only limes of very approximately the same chemical analyses were selected for test purposes. The calcium oxides all analyzed between 95 and 96 per cent. All the magnesias ran below 1 percent, so that with the practical elimination of chemical analysis as a serious variable, it is felt that the tests as herewith recorded do to a marked degree indicate—(1) that two main factors, namely, porosity and degree of burning, play an important part in determining the economic value of lime used in wire drawing, (2) that time-temperature modifies porosity, (3) that a porous limestone can reflect its porosity into a burned product to advantage (samples 1 and 2 were manufactured from low density limestones.)

✦ ✦ ✦

THIS discussion is presented with the hope of familiarizing the wire industry with the study which the progressive lime manufacturer is giving its manufacturing problems, in the interest of improving lime products for use in the wire industry, and industry as a whole.


VASCOLOY-RAMET DIES AND MANDRELS

**For Better Dies For Every Job**

*Say*

VASCOLOY-RAMET

***The Tantalum Carbide Die Material • • •***

Harder than the hardest of steels, immune to the action of most industrial acids, Vascoloy-Ramet is daily winning a wider acceptance throughout the wire world.

There is a Vascoloy-Ramet Die for every job, and especially for yours.

**VANADIUM ALLOYS STEEL COMPANY**
**Vascoloy-Ramet Division**
***North Chicago, Illinois***

*District Sales Offices:*

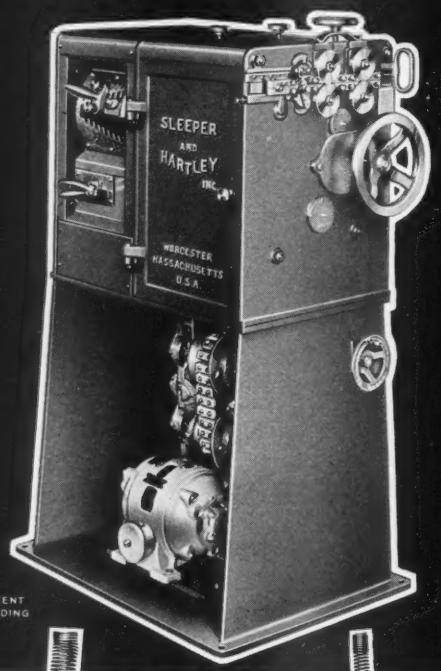
Pittsburgh.....Pa.
New York.....N. Y.
Springfield.....Mass.
Providence.....R. I.
Philadelphia.....Pa.
Cleveland.....Ohio
Detroit.....Mich.
Chicago.....Ill.
St. Louis.....Mo.
Buffalo.....N. Y.
Newark.....N. J.
Knoxville.....Tenn.
Los Angeles.....Cal.
San Francisco.....Cal.

# No. 1 UNIVERSAL SPRING COILER

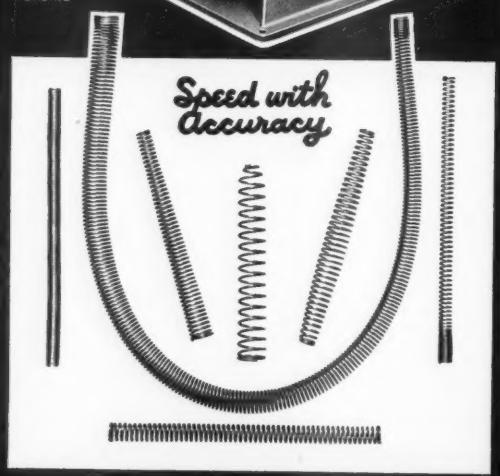
## Series 610

## *Selective Type*

Over 70 different types of special machines suited to a variety of wire coiling problems.




See This Machine In Operation at the National Metal Congress in Atlantic City, N. J., October 18th to 23rd.




**SLEEPER & HARTLEY, Incorporated**

Worcester, Massachusetts, U. S. A.

SPRINGS AND WIRE PRODUCTS

Devoted to Products Made Wholly or in Part of Wire, Rod, Strip and Cold Drawn Steel.

J. W. Rockefeller, Jr., Section Editor.

Vol. 12 OCTOBER, 1937 No. 10

# Fatigue Properties of Helical Springs

By Rodman R. Tatnall

Metallurgical Engineer, Morgan Division,
Wickwire Spencer Steel Co., Worcester, Mass.

A discussion of helical compression and to a certain extent, extension, springs of round wire section and a consideration of springs made of the common types of carbon steel wires. It is hoped by the author that other investigators will contribute their experiences so that makers and users of springs and spring wires may have definite fatigue information available.

## Introduction

BECAUSE of the importance of springs in many of the present-day machines and mechanisms, the question of spring fatigue is of prime interest. The successful functioning of many devices depends on spring stamina, and there have been innumerable cases of springs breaking in service with consequent improper operation of the device. The casual explanation of this spring breakage places the blame on defective material, but in most cases examination and test fail to reveal defects. It is the purpose of this paper to explain the failure of springs under fatigue conditions.

✦ ✦ ✦

SINCE there are many types of springs, with various kinds of loading conditions, it is necessary to limit the discussion at the outset to helical compression, and to a certain extent, extension springs, of round wire section, and also to consider only the common types of carbon steel wires. Since the work to be reported has dealt with wires larger than No. 12, no mention is made of music spring wire, which, of course, is an important standard material in smaller sizes.

RODMAN R. TATNALL

Born in New Rochelle, N. Y., in 1906. Educated at Worcester Polytechnic Institute. First employment one year in Development Dept. of Waltham Watch Co. In 1928, joined Wickwire Spencer Steel Co. in spring production dept. In 1930, was promoted to position of Metallurgical Engineer, and since then has been in charge of experiment and research on spring and spring materials. Member of Wire Association and American Society for Metals.

THE present author developed a comparatively easy method of testing, (1), which has been used throughout this investigation. In this method, twelve springs are tested at one time, setting the loading on each spring so that the endurance limits for three different ranges of stress are determined. From this data, an endurance diagram is plotted and used for comparison of one material with another. For this purpose, the diagrams may be compared directly, or a derived figure can be used as an index.

✦ ✦ ✦

## Factors Affecting Fatigue

THERE are a multitude of interwoven factors entering into the behaviour of springs under fatigue operation, and Figure 1 gives an outline of them. These factors divide naturally into mechanical factors, such as design considerations, and metallurgical factors such as analysis. By far the more important are the mechanical factors. The working stresses of the springs in their relation to the endurance limit of the material determine whether the spring is 'safe' or not. The value of the endurance limit itself depends on the metallurgical factors mentioned above, but

varies in a comparatively small degree. Consequently, these factors rarely compensate for a case of improper spring design.

+ + +

IN the following discussion, these factors will be analyzed, so far as we are able and their effects on the fatigue of a spring gone over in detail.

+ + +

## Design of Spring

IN all uses of springs where fatigue is important, the mechanism requires a working range, either a definite load range, or a define linear motion. In either case, the spring works in a cycle of repeated loading, or repeated stress. This stress is torsional, complicated by a varying amount of direct shear. The value of the torsional stress can be readily calculated from the dimensions of the spring and the load values. The complication of direct shear can be allowed for by the application of the proper multiplying factor as developed by **Wahl**, (2). Space does not permit any lengthy discussion of spring design, but those who are familiar with the subject know that several springs of varying dimensions can usually be designed to do a certain job. These several designs will perhaps have varying load rates, and certainly will have varying stress values.

FACTORS AFFECTING FATIGUE OF SPRINGS

I. DESIGN OF SPRING
- A. STRESS VALUES
- B. STRESS CONCENTRATION

II. MANUFACTURE OF SPRING
- A. ACCURACY OF DIMENSIONS
- B. STRESS RELIEF
- C. TOOL MARKS

III. DESIGN OF MECHANISM
- A. WORKING RANGE
- B. SPEED OF OPERATION
- C. SURGING OF SPRING

IV. METALLURGY
- A. TYPE OF MATERIAL
- B. PHYSICAL PROPERTIES
- C. SOUNDNESS—PURITY
- D. SURFACE CONDITIONS
- E. MANUFACTURE
  1. MILL OPERATIONS
  2. HEAT TREATMENT

Fig. 1. Elements In The Service Of Springs Affecting Fatigue.

+ + +

FIGURE 2 shows the working characteristics of two springs designed to do the same work. Both are calculated to hold a load of 31 lbs. at 2.13" length, and 65 lbs. at 1.84" length. One spring, according to the conventional formula, works from 21,000 p. s. i. stress to 40,000. The other works from 35,000 to 68,000. The Wahl factor for the first is 1.26, and for the second, 1.305. The application of these factors gives true stress values for the first spring of 26,400 to 50,300 and for the second, 45,600 to 88,600 p. s. i. It will be readily seen from the diagram that the maximum true stress of the second spring has exceeded the endurance limit.

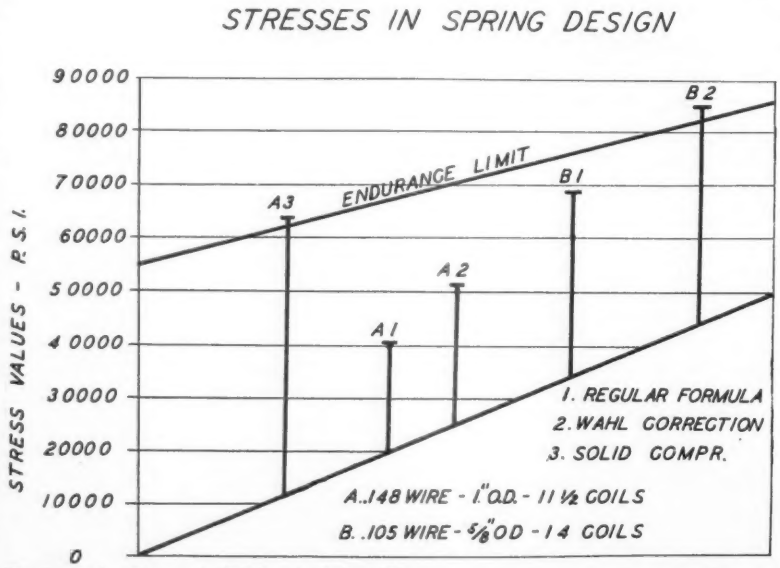



Fig. 2. Spring Stresses in Relation to Fatigue Diagram.

+ + +

THUM, (3), gives a general discussion of spring design and spring failure, and points out that the most common cause of spring failure is overloading. Ordinarily, the design of a spring is limited by the relation of the maximum stress value to the elastic limit of the material. However, it can not be emphasized too strongly that the relation of the stress values, working range as well as maximum, to the endurance limit is the important point to con-

sider. For the majority of spring applications, the endurance limit is considerably lower than the elastic limit.

✦ ✦ ✦

THE customary and necessary tolerances allowed in spring manufacture mean that the stress values calculated from specified dimensions may vary 8-10% either way. In other words, after an analysis as shown in Figure 2, it must be remembered that some springs may run as much as 10% higher in maximum stress value.

✦ ✦ ✦

IN Figure 2, the line marked A3 represents solid compression of the spring. For spring B, the stress at solid compression is 134,000 p. s. i., a value outside the limits of the diagram. For spring A, it is 63,000, a value slightly over the endurance limit. As will be shown in the next few paragraphs, it is sometimes possible that the spring will attain this stress in operation. Hence, although spring A seems to be a correct design, there may be circumstances under which it will fail.

✦ ✦ ✦

## Operating Conditions

THE speed of operation of the mechanism must be considered in two lights. One is the effect the speed may have on the spring as a machine part, with which we will deal a little later, and the other is the rather obvious fact that speed determines whether fatigue is an important factor in the operation of the spring. There are many uses of springs in which the design gives stress values greater than the endurance limit. However, the speed of operation is so slow that failure does not occur within the normal life of the machine.

✦ ✦ ✦

## Spring Surge

THE effect of speed on the spring itself also depends on the nature of the motion. If the motion is irregular or imparts shock to the spring, surging, or vibration, is set up in the coils of the spring. This is particularly true when the speed is comparatively high, and at certain speeds a condition of pseudo-resonance is found in which the vibrations may be serious.

✦ ✦ ✦

DONKIN and Clark (4) have contributed a detailed discussion of surging in automobile valve springs, and point out that vibration is an inherent characteristic of springs. The situation can be helped by designing springs to have a high natural frequency compared with the speed of operation. An automobile cam gives a sharp motion to the valve spring, with abrupt changes from the rest and peak positions, and operates not only at high speeds, but at variable speeds, resulting in ideal circumstances for surging to take place.

✦ ✦ ✦

WHEN the spring coils are vibrating, changes take place in the stress conditions. Also to be considered is the fact that under vibration each coil of the spring passes through its stress range, not at the speed of operation, but at a speed equal to the natural frequency of the spring, which may be between 10,000 and 20,000 cycles per minute for a spring of this type.

✦ ✦ ✦

BY means of stroboscopic, or slow motion, apparatus, the actual motion of a spring may be observed in detail under operating speed. Fig. 3 shows a number of curves traced by the mid-coil of a spring deflected by an automobile valve gear at various speeds. The first curve shows proper operation, without surge, the second a slight surge which dies out before the next cam lift, and the third a vibration which does not die out, but still is not serious enough to be harmful. The next two curves are serious vibrations which lead to failure of the spring. In these curves the cam lift is barely discernible, and the spring coils are clashing together. In other words, two coils of the spring are receiving the equivalent of solid compression as the vibration passes. The last curve is included to show an unusual type of vibration, illustrating the peculiar combinations of motion which may be induced.

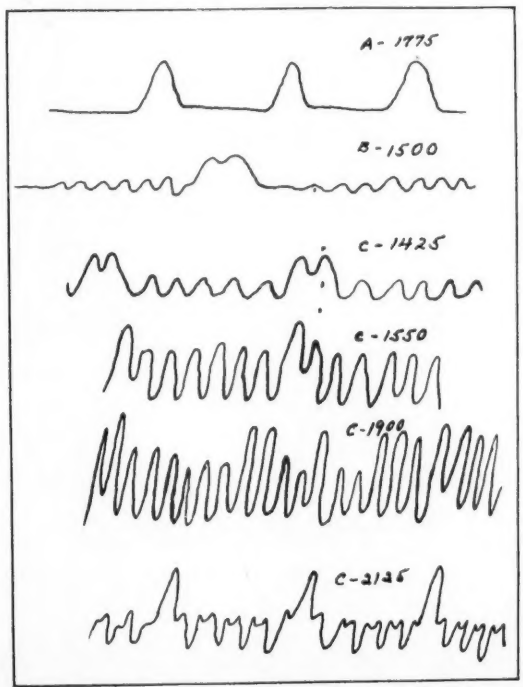



Fig. 3. Motion of a Coil of a Valve Spring Under Conditions of Vibration. Observed by Slow Motion Apparatus. ✦

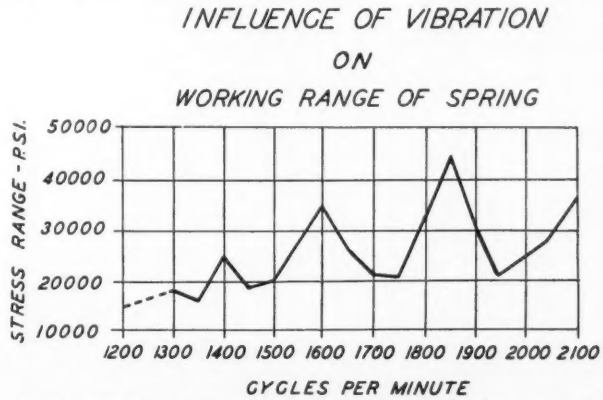
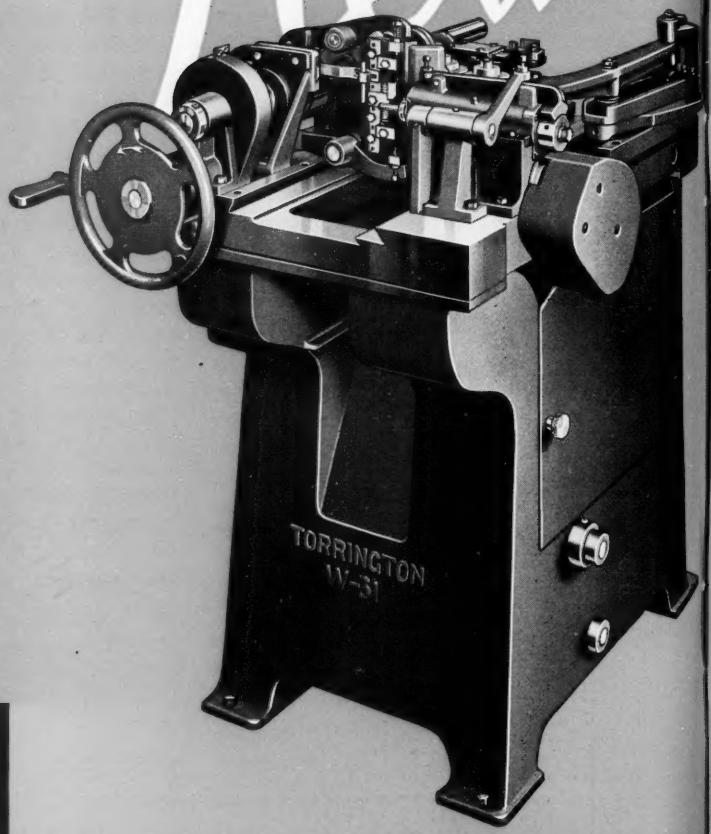
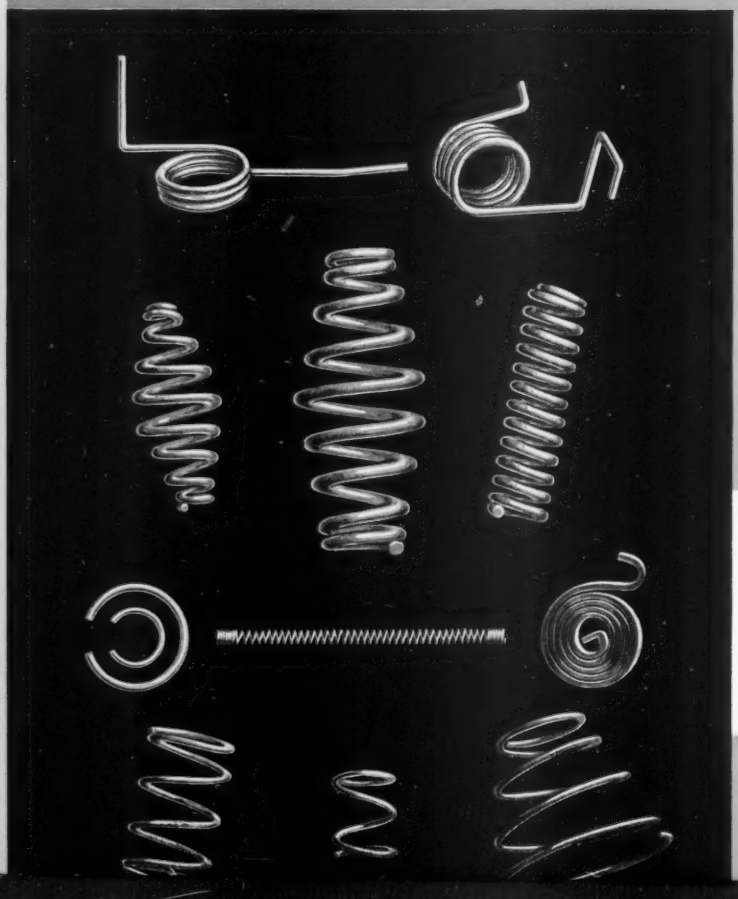



Fig. 4. Expansion of working range by the effect of vibration. ✦

# News



PATENTS PENDING

**COILERS IN EIGHT SIZES**
**Range .006 to ⅜" Diameter Wire**

**TORSION MACHINES IN FOUR SIZES**
**Range .006 to ¼" Diameter Wire**

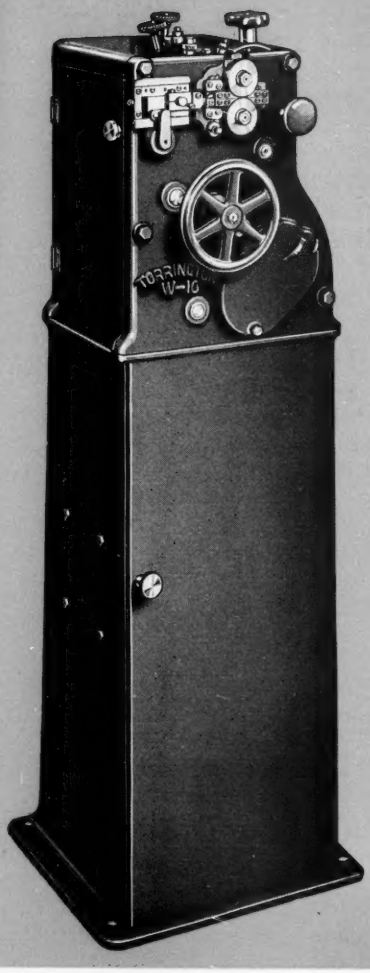
***Visit our display at the 19th Annual Metal Exposition, Atlantic***

# FOR SPRING MAKERS

## TORRINGTON

## NEW-IMPROVED-MODERN

## High-speed Automatic Anti-friction Spring Making Machinery



### *SEGMENT AND CLUTCH TYPE COILERS*
### *TORSION SPRING MACHINES*

- ★ High-speed production
- ★ Rugged, rigid construction
- ★ Timken Roller Bearing equipped
- ★ Convenient, accessible controls for pitch, diameter, cut-off, etc.
- ★ Simple feed adjustment
- ★ Safety hand wheel
- ★ Compact design — fully enclosed, built-in motor
- ★ Ample wire and coil capacity in each machine
- ★ Square, clean cut ends
- ★ Production speed variable either by change gears or standard variable speed unit
- ★ Wire feed on clutch type adjustable through fixed center change gears or sliding gear box

Attachments available for coiling square or odd shaped wire, rings, long length springs, etc.

## THE TORRINGTON MANUFACTURING CO.

TORRINGTON, CONNECTICUT • U. S. A.

MEASUREMENTS on these curves show that the working range of the spring has been widened by this surge. That is, the minimum stress has been lowered, and the maximum stress increased, because of the additional motion the surging induces. The result of measurements made on an extensive set of curves similar to Figure 3 for a wide range of speeds is shown in Figure 4.

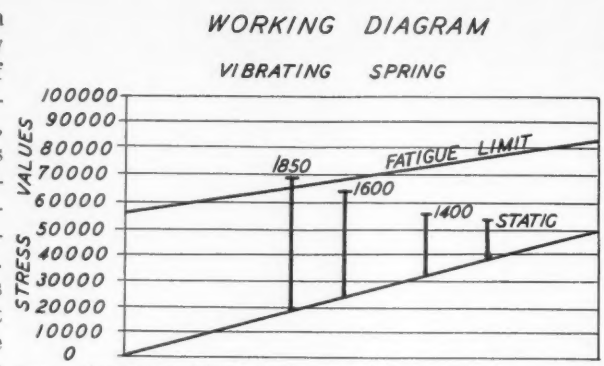


Fig. 5. Comparison of Dynamic Stresses and Fatigue Diagram.

✦ ✦ ✦

THE value starting the dotted line in this figure represents static, or specified loading. As the speed increases, the working range broadens, and we find at certain critical speeds peaks of increased range. It is notable that each succeeding peak shows a greater increase in range, although the 'valleys' remain about the same. This is explained by the relation of the speed at which the peak occurs to the natural frequency of the spring. Thus the peak at 1400 occurs at a speed about ⅛ of the natural frequency, at 1600, about 1/7, and at 1850 at about 1/6. The larger this fraction becomes, that is, the nearer the critical speed approaches the frequency of the spring, the more serious becomes the surging. At 1600 the coils can be seen to flutter slightly, and the spring emits a distinct hum. At 1850 the coils clash together unmistakably. For this it would seem that the stress at solid compression is the limiting stress to which the spring can be forced by vibration.

✦ ✦ ✦

TO show more clearly how vibration may affect the fatigue of a spring, the working ranges of the peaks of Figure 4 have been plotted on a typical fatigue diagram in Figure 5. Here we see that static, or design, values give a perfectly safe spring. However, under critical speeds and vibration, the working range spreads until in certain cases it exceeds the endurance limit, and the spring fails, even though of conservative design statically.

✦ ✦ ✦

VIBRATIONS have been observed in many spring uses other than valve springs, in some of which it has caused failures, and in others has been harmless. Each application is a case by itself, and there is no hard and fast rule for guidance. In a constant speed mechanism, proper springs can be chosen, at the least, by trial and error. In a variable speed mechanism, correction is much more involved. In any event, the possibility of spring vibration must be considered when failure is being studied.

✦ ✦ ✦

## Other Mechanical Factors

THE foregoing discussion has shown the most important points to consider in the operation of a spring under fatigue conditions from a mechanical point of view. There are one or two other points which, with present quality controls, are not so important. These may be mentioned as tool nicks and marks, squareness of grinding, stress relief after forming, and general workmanship, all of which may cause a discrepancy between actual and designed stresses, or may set up stress concentrations.

✦ ✦ ✦

## Type of Material

THE predominating metallurgical element which determines the value of the endurance limit is the type of material. In its larger sense, this includes alloys, and nonferrous materials, as well as the carbon steels. It also means various classes of carbon steel wires which are differentiated largely by the manufacturing method. Figure 6 is a set of endurance charts for various classes of spring wires, and shows average values developed by a large number of tests on each type. With the exception of stainless steel, the charts represent material of nearly the same analysis. The oil tempered

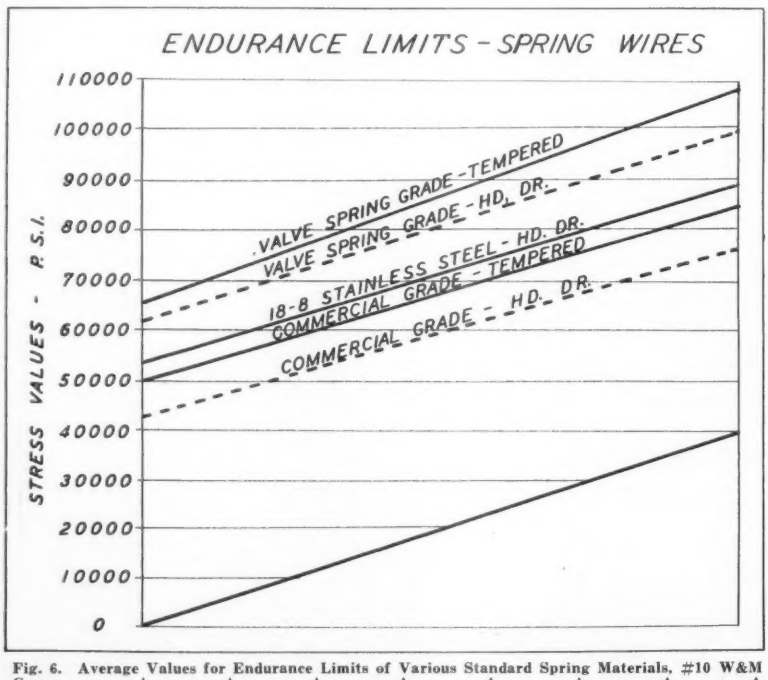


Fig. 6. Average Values for Endurance Limits of Various Standard Spring Materials, #10 W&M Gauge.

✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

wire and hard drawn are different because the one receives its strength from heat treatment, and the other from cold work. The commercial and valve spring grades are different because of the method of processing, but in this case the difference is found, not so much in the wire mill as in the steel mill. It will be seen that there is considerable difference in endurance limits for each type.

✦ ✦ ✦

## Selection of Samples

FIVE steels have been used in studying various phases of the fatigue problem, and Table 1 shows the designation given them, as well as the analysis of each. Steels A. C, and E were ordinary spring wire heats for commercial wire of various types. They were used here primarily for their variation in analysis. Steels B and D were special valve spring wire heats, of domestic steel. Steels B and D were used in a study of hardness or strength in its relation to endurance limit, steels A and C for a general study of various factors, and steel E for a study of cold working.

✦ ✦ ✦

FOR the testing method employed, No. 10 wire was chosen as a convenient size. The diameter of the standard test spring for this size wire is 1⅞". Each lot of springs for test was given a stress relief treatment at 600° F. for 15 minutes, to eliminate trapped stresses from the coiling operation. All tests on heat treated wire were run a minimum of two million cycles, since experience shows that such a length of test is sufficient to determine the endurance limit. Tests of cold worked wire were run four million cycles minimum.

## Cold Working

THE effect of cold working on the fatigue strength of metals has been reported by many investigators studying bending fatigue. **Moore** and **Kommers,** (5), report that commercial cold drawing or cold rolling of steel seems to increase the fatigue strength to about the same extent as the ultimate strength is increased. **Stenger** (6) quotes other investigators to the effect that cold rolling increases fatigue strength, while cold drawing seems to lower it. **Adam** (7) shows that fatigue limit in bending is increased by one-third with 85% reduction of a steel free from decarburization.

✦ ✦ ✦

IN order to examine the effect of varying amounts of cold work, samples of steel E were prepared in the following manner. The ¼" rod was drawn to No. 4, 5, 6, 7 and 8. These sizes were then air patented and drawn further 6, 5, 4, 3, and 2 drafts respectively, to .135" (No. 10). Drafts were taken by gage numbers so that all drafting was in approximately equal steps. Each sample was then tested for physical properties, and coiled into springs for test. An additional sample was made by drawing from the patented rod 4 drafts, according to commercial practice.

✦ ✦ ✦

THE result of physical tests is shown in Figure 7 and Table 2. Fatigue tests gave the diagrams presented in Figure 8. In this figure, the line marked B represents the commercial sample. Because of the confusion of lines in the chart, the index of each test, an arbitrary figure derived from each diagram, is plotted in Figure 9. This shows more clearly the trend of the fatigue strength with increased amounts of cold work, and in these results, indicates that this trend is nearly neutral. A complete investigation of this has not at this time been carried out, although **Adam** states that a decarburized steel shows a neutral effect of cold work on the fatigue strength in bending.

✦ ✦ ✦

IT is to be noted in this figure that the value for the commercially drawn sample, shown by the asterisk on the graph, is somewhat lower than the hardest of the other samples. This indicates that drafting practice may affect fatigue strength, or it may result from a difference in the patenting. **McCarthy** (8) showed how both these operations may affect the quality of a wire through the possibility of sub-microscopic cracks due to the cold working.

✦ ✦ ✦

## Heat Treatment

THE influence of heat treatment on fatigue strength is an involved subject. The only attack is by a correlation of the physical properties obtained by the treatment with fatigue strength. Aside from poor heat treating practice, such as too short a time for complete solution of the constituents prior to quenching, the treatment may affect surface condition by decarburization, and will affect grain size, both of which will be discussed later.

✦ ✦ ✦

THE primary purpose of heat treatment is to increase strength. Toughness and ductility are sacrificed for the gain in elastic strength in the case of springs. The assumption has been that fatigue strength has increased also. Practically all applications of springs in fatigue duty use heat treated material where sizes are over No. 12. The following discussion relates to samples heat treated before coiling, in a manner as nearly approaching commercial treatment as possible, and using commercial material. We believe the conclusions reached apply equally well to material heat treated after forming.

Table 1
ANALYSIS OF STEELS INVESTIGATED

| Steel | Carbon | Mang. | Sulphur | Phosphorus | Silicon |
|---|---|---|---|---|---|
| A. | .50 | .89 | .035 | .036 | .14 |
| B. | .63 | .72 | .022 | .014 | .18 |
| C. | .74 | .73 | .032 | .016 | .13 |
| D. | .65 | .79 | .023 | .018 | .17 |
| E. | .61 | .84 | .033 | .037 | .15 |

Basic Open Hearth Steels.

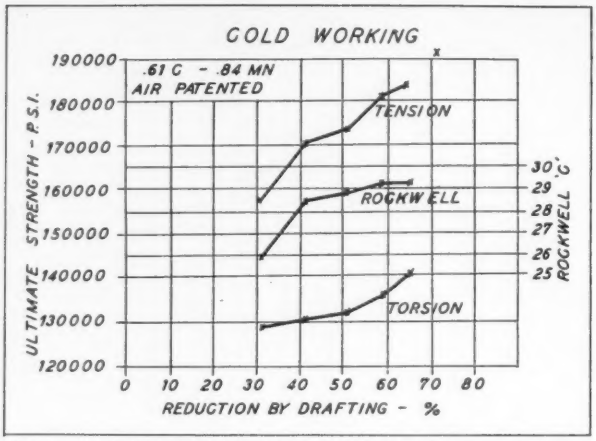



Fig. 7. Physical Properties Resulting from Cold Working.

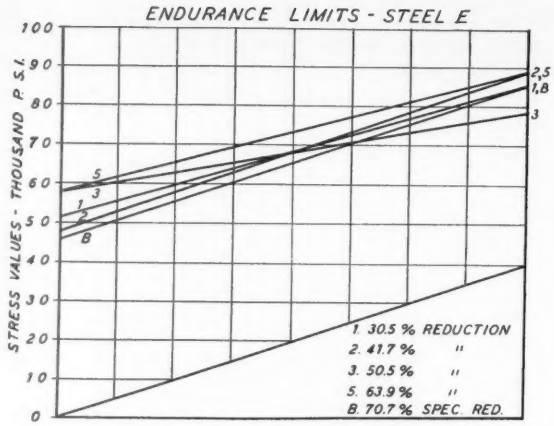



Fig. 8. Fatigue Diagrams of Cold Worked Wire.

## Treatment and Testing

PRELIMINARY tests were run some time ago, using steel D, in an effort to trace the effect of hardness on fatigue strength. Test springs were hardened after coiling, and the hardened springs were drawn at temperatures ranging from 600° to 1200° F., giving a wide range of hardness. Results of these tests are given later in comparison with recent work.

✦ ✦ ✦

BECAUSE some complications had been introduced by the above procedure, and because a selection of samples more related to the commercial product seemed desirable, steel B was used. Steels A and C were included in the run because of their analysis, and the general interest in heat treatment results.

✦ ✦ ✦

THE wires were run through a commercial continuous quenching and tempering unit, with the quenching temperature at 1650° F. With the draw temperature at 700°, sufficient sample was run off. The wire was then stopped and the draw temperature raised to 800°. This was continued for 900° and 1000°, discarding each time the length of wire which was stopped in the furnace. Quenching temperature and speed of the wire remained constant thruout the run.

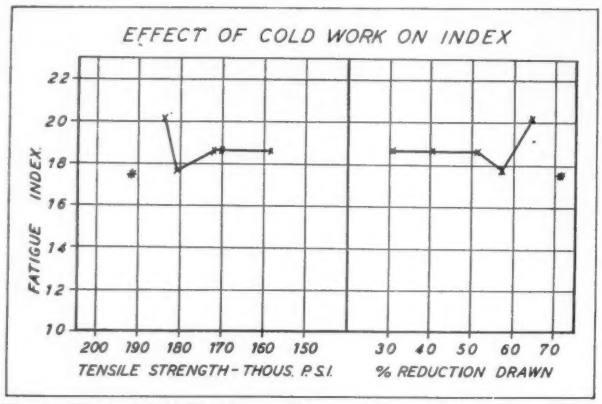



Fig. 9. Effect of Cold Working on Relative Value in Fatigue.

✦ ✦ ✦

PHYSICAL tests were then made in the usual way, and the results are shown in Figures 10 and 11, and tabulated in Table 3. It is to be noted that the strength curves fall quite uniformly into line in the light of analysis and drawing temperature. The ductility curves are rather irregular, with the .63 carbon (valve spring) steel showing a tendency toward superiority in twist and reduction of area.

✦ ✦ ✦

## Fatigue Test Results

RESULTS of fatigue tests are shown in Table 4 and the diagrams given in Figures 12, 13, and 14. Steel A shows an irregular location of endurance limits for each sample, while steel B shows good uniformity. Steel C shows uniformity, but the variation with hardness is somewhat irregular. It is the author's belief that in steels A and C the irregularity is due to other variables than hardness, and its effect is overshadowed. With steel B the true

Table 2
PROPERTIES OF COLD WORKED WIRES

| Sample | Tensile Strength | Torsional Strength | Rock. C | % Red. draft | Endurance Limits 0 Min. | Endurance Limits 40,000 Min. | Fatigue Index |
|---|---|---|---|---|---|---|---|
| E-1 | 157,000 | 129,000 | 26.0 | 30.5 | 52,000 | 84,100 | 1840 |
| E-2 | 171,000 | 131,200 | 28.5 | 41.7 | 47,600 | 88,500 | 1840 |
| E-3 | 173,000 | 132,700 | 28.9 | 50.5 | 57,600 | 78,600 | 1840 |
| E-4 | 181,000 | 135,200 | 30.2 | 57.4 | 48,700 | 85,200 | 1795 |
| E-5 | 184,500 | 141,500 | 30.2 | 63.9 | 57,600 | 88,500 | 2040 |
| B | 191,500 | 145,200 | 30.0 | 70.7 | 46,500 | 85,200 | 1750 |

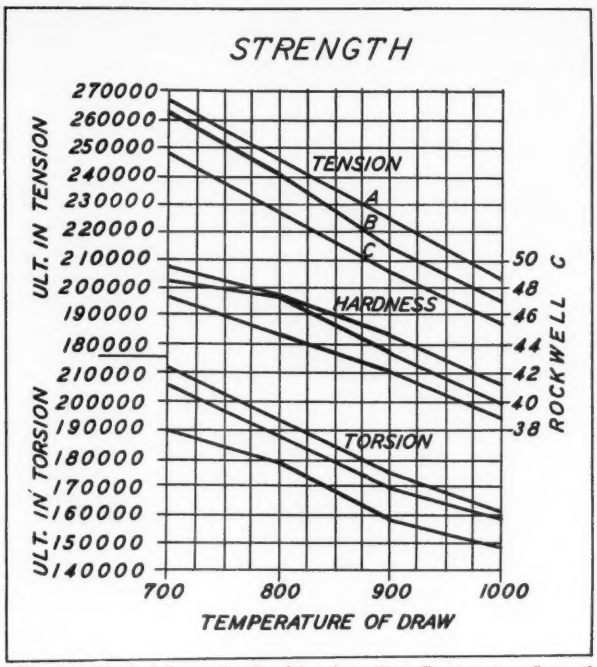



Fig. 10. Physical Properties Resulting from Heat Treatment — Strength. Oil Quenched from 1650°.

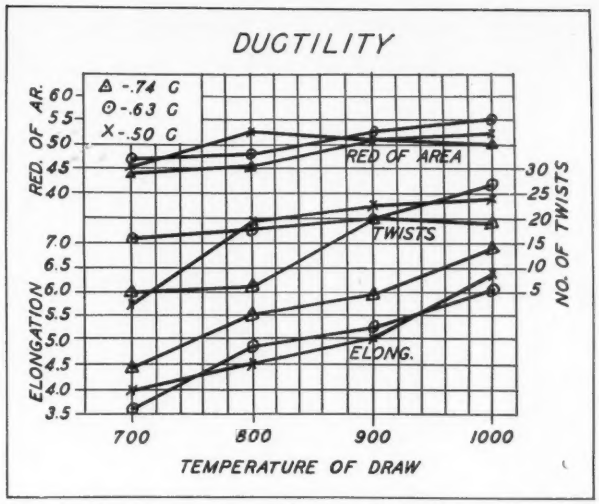



Fig. 11. Physical Properties Resulting from Heat Treatment — Ductility. Oil Quenched from 1650°.

effect of hardness variation is brought out.

✦ ✦ ✦

IN order again to avoid the confusion of lines, and to make a more direct comparison of the steels, the three latter figures are re-plotted in Figure 15 to show the range of endurance limits found for the various samples of the three steels. This figure will be referred to later in discussing other characteristics.

✦ ✦ ✦

## Hardness

IN order to bring out the effect of hardness shown by steel B in Figure 13, use has been made again of the derived index. This figure is plotted with Rockwell hardness in Figure 16. Here also is shown the result of the work done with steel D, mentioned previously. This graph shows clearly the extent to which endurance limits are increased as the materials are made softer. There is apparently a maximum value in the neighborhood of 38-42 Rockwell C. The explanation of the maximum lies probably in the fact that, as the wire becomes softer, elastic limits are lowered until settage takes place in the fatigue test, with resulting complications of slight cold working, uneven stressing, and perhaps stress values different from those calculated.

✦ ✦ ✦

STENGER (6) published work done in bending fatigue on heat treated samples of rectangular bars, and found that there was an optimum drawing temperature, indicating a maximum endurance limit similar to the present findings. Their work was with considerably higher carbon material, and a specialized method of testing was developed, but their results are analogous.

✦ ✦ ✦

THE other two steels in our investigation showed a marked tendency toward this same phenomenon. It is not as clear cut as was found with steel B, which is perhaps due to influences other

Table 3
PHYSICAL PROPERTIES OBTAINED BY HEAT TREATMENT

| Sample | Tensile Strength | Torsional Strength | Rock. C | Torsional Elas. Lim. | Elong. 10″ | Twists 10″ | Draw Temp. |
|---|---|---|---|---|---|---|---|
| A-1 | 248,500 | 190,500 | 47.5 | 116,300 | 3.9% | 5.5 | 700° |
| A-2 | 228,000 | 178,500 | 44.5 | 106,800 | 4.5 | 19.2 | 800 |
| A-3 | 206,500 | 158,500 | 42.0 | 96,800 | 5.0 | 22.0 | 900 |
| A-4 | 186,500 | 148,000 | 39.0 | 94,900 | 6.4 | 24.0 | 1000 |
| B-1 | 262,000 | 206,700 | 48.6 | 122,000 | 3.6 | 16.5 | 700 |
| B-2 | 240,500 | 188,700 | 46.8 | 104,800 | 4.8 | 18.0 | 800 |
| B-3 | 214,000 | 171,000 | 43.2 | 97,700 | 5.2 | 19.5 | 900 |
| B-4 | 195,500 | 157,500 | 39.9 | 92,800 | 6.1 | 27.0 | 1000 |
| C-1 | 267,000 | 211,000 | 49.2 | 132,500 | 4.4 | 9.0 | 700 |
| C-2 | 246,000 | 193,500 | 46.6 | 126,700 | 5.5 | 11.0 | 800 |
| C-3 | 223,000 | 174,200 | 44.4 | 111,000 | 5.9 | 20.5 | 900 |
| C-4 | 201,500 | 160,000 | 40.9 | 98,700 | 6.9 | 19.0 | 1000 |

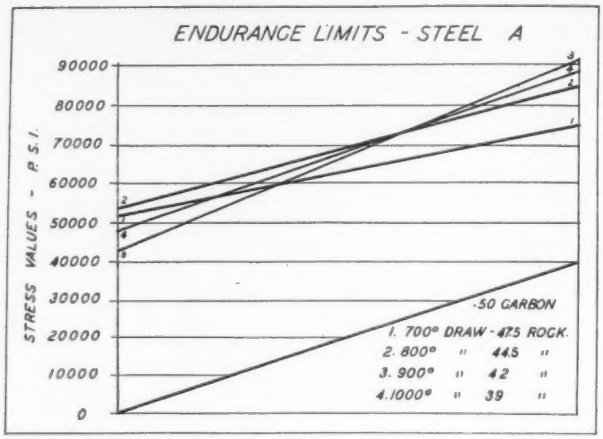



Fig. 12. Fatigue Diagrams, Heat Treated Wire. Steel A.

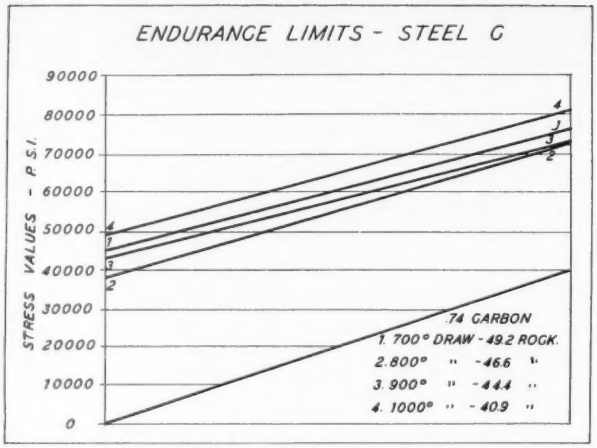



Fig. 14. Fatigue Diagrams, Heat Treated Wire. Steel C.

than hardness alone. It is more pronounced with steel C than A, but it is sufficiently strong in all to warrant the general conclusion that when the hardness (and strength) of a wire is increased by heat treatment, that is, by lower draw temperature, endurance limit is lowered.

✦ ✦ ✦

## Grain Size

GRAIN size plays an important part in many properties of a metal, and it is to be expected that its influence would be felt in fatigue also. In Figure 16 we found steel D with considerably lower index than B. Steel D shows a maximum index of 23, while commercially treated wire from the same heat showed slightly over 27, and steel B shows 26.8 for the highest value found. The reason for the difference lies in the heat treatment. The commercial wire is hardened through a comparatively short time cycle, while the springs tested for Figure 16 were hardened in an oil-fired muffle furnace at a slightly higher temperature and a much longer time cycle. No record of the grain size resulting is available, but it was apparent from fractures that the grain of steel D was considerably coarsened.

✦ ✦ ✦

IN Figure 15, steel B shows higher endurance limit than either A or C, and A shows higher than C. This is contrary to expectations, since C is the higher carbon and higher strength material. Figures 17, 18, and 19 show the austenitic grain size developed in these steels in the heat treatment given. These micrographs were made by the procedure outlined by **Bain** and his associates (9), duplicating the temperature and time of heating for quench, and by means of an interrupted cooling, causing dark etching pearlite to form in the grain boundaries with light etching martensite in the interior of the grain. Steel A in Figure 17 shows a grain size about #5 on the A. S. T. M. scale, and steel C shows about #3. Steel B seems to have a mixed grain in Figure 18, but previous **McQuaid-Ehn** tests gave between #7 and #8. Due to the fine grain, the reaction rate of this steel is so fast that it is extremely difficult to catch it at the proper fraction of a second to show the grain size by this method.

✦ ✦ ✦

THE fatigue results follow the differences in grain size in these three steels. It is impossible to correlate these tests and samples any more closely because there are too many other differences be-

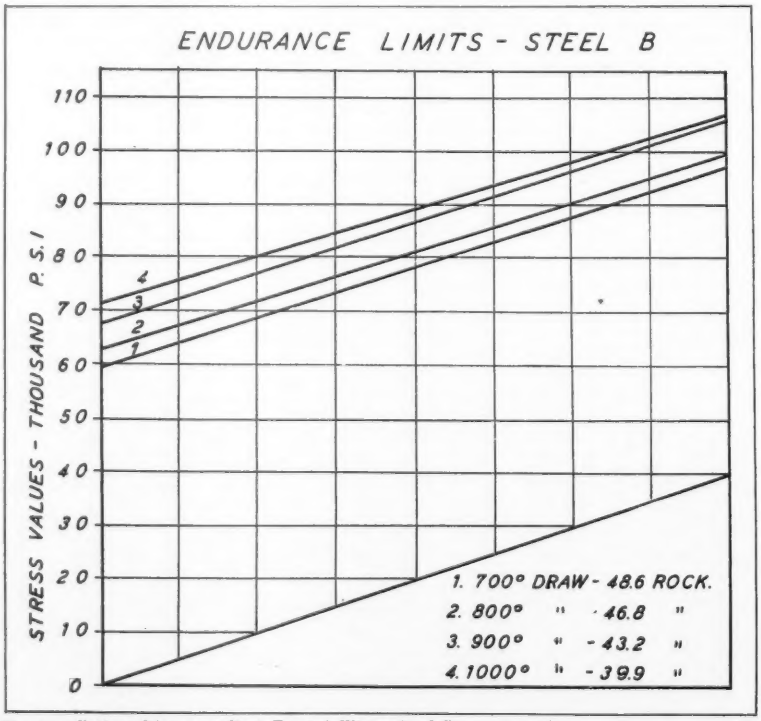



Fig. 13. Fatigue Diagrams, Heat Treated Wire. Steel B.

# ONLY BIG FIGURES DESCRIBE FIRTHALOY PERFORMANCES

FIRTHALOY
PERFORMANCE DATA
Over 2,500,000 springs produced by a FIRTHALOY Wire Guide and Cut-off Tool on a #2 S&H Torsion Machine. Wire diameter .091".
FIRTHALOY
PERFORMANCE DATA
Over 6,000,000 wire bottle openers made on a four-slide machine with FIRTHALOY Tools, and the tools are still in production.
FIRTHALOY
PERFORMANCE DATA
Over 3,000,000 springs, wire diameter .03125", coiled and cut off with this FIRTHALOY Tipped Arbor.
FIRTHALOY
PERFORMANCE DATA
Over 50,000,000 eyelets produced with a FIRTHALOY die. The die is still in production with only .0005" loss in hole size.
FIRTHALOY
PERFORMANCE DATA
Over 4,000,000 wood screws produced with a FIRTHALOY
-heading die and the tool is
production.

# FIRTH-STERLING STEEL COMPANY

Works: McKEESPORT, PA.
NEW YORK CHICAGO HARTFORD
CLEVELAND DETROIT LOS ANGELES
PHILADELPHIA DAYTON
GLOBE WIRE DIVISION, McKEESPORT, PA.

Table 4
RESULTS OF FATIGUE TESTS

| Sample | Endurance Limit 0 Minimum | Endurance Limit 40,000 Minimum | Fatigue Index |
|---|---|---|---|
| A-1 | 50,900 | 81,800 | 1820 |
| A-2 | 53,200 | 86,300 | 1905 |
| A-3 | 44,400 | 89,700 | 1795 |
| A-4 | 46,500 | 87,400 | 1795 |
| B-1 | 59,800 | 97,400 | 2260 |
| B-2 | 63,100 | 99,700 | 2370 |
| B-3 | 67,600 | 107,000 | 2605 |
| B-4 | 72,000 | 106,300 | 2680 |
| C-1 | 45,400 | 78,600 | 1595 |
| C-2 | 33,700 | 82,400 | 1440 |
| C-3 | 43,200 | 74,700 | 1475 |
| C-4 | 50,900 | 81,900 | 1775 |

tween the three lots of samples. However, the influence of grain size seems to be quite important, and work is under way for a study in which grain size will be the only variable.

✦ ✦ ✦

## Soundness and Purity

SOUNDNESS and purity in reality mean defects or lack of defects in the material. Soundness implies absence of physical defect, and purity absence of chemical defect. Physical defects may be such things as seams, pipe, etc., while chemical defects may be inclusions, segregation, and the like. Many of these defects, of both classes make themselves apparent before the material reaches the stage of springs. As far as most of these defects enter the fatigue picture, their influence is minor. If they are small enough to escape the usual tests and inspection and can only be detected by extreme methods, their influence is less than that of other factors with which we have to contend. If they are seriously large, of course, they will lower endurance values, and if such occurs, the trouble is usually apparent in the fracture. A case in point is shown in Figure 20. The fractures here are rather ragged in appearance because of the peculiar stressing conditions in a square wire spring. In the smaller piece a seam is apparent in the center of the nearest side.

✦ ✦ ✦

ON the other hand, some obvious defects do not result in the failure one would expect. Figure 21 shows a spring deep etched after fatigue test, in which a seam is found. This spring did not fail under many millions of cycles of stress under which other springs of the same design did fail in the same test.

✦ ✦ ✦

THE characteristic fatigue fracture is often referred to in discussing spring failures. Figures 22, 23, and 24 show some fractures obtained in our tests. Figure 22 is the failure of oil tempered wire at stresses over the endurance limit, and shows a nearly plane fracture at an angle of about 45° to the axis of the spring and also to the axis of the wire. It shows the smooth portion found in all fatigue failures, starting near the inside of the coil, and the rougher portion where the final rapid fracture took place. Figure 23 is the fracture of a hard drawn wire and appears more fibrous than the tempered wire. This fibrous appearance is a natural result of the fracture spreading from one cold worked grain to another. Figure 24 is the fracture of oil tempered wire which was accidentally stressed considerably over the elastic limit. It is extremely fibrous and shows a number of small splits. This is not defective material, but is characteristic of fractures under such high stress.

✦ ✦ ✦

## Surface Conditions

SURFACE conditions of wire have received a great deal of attention in the industry in the past few years, on the theory developed from bending fatigue tests that poor surface conditions led to

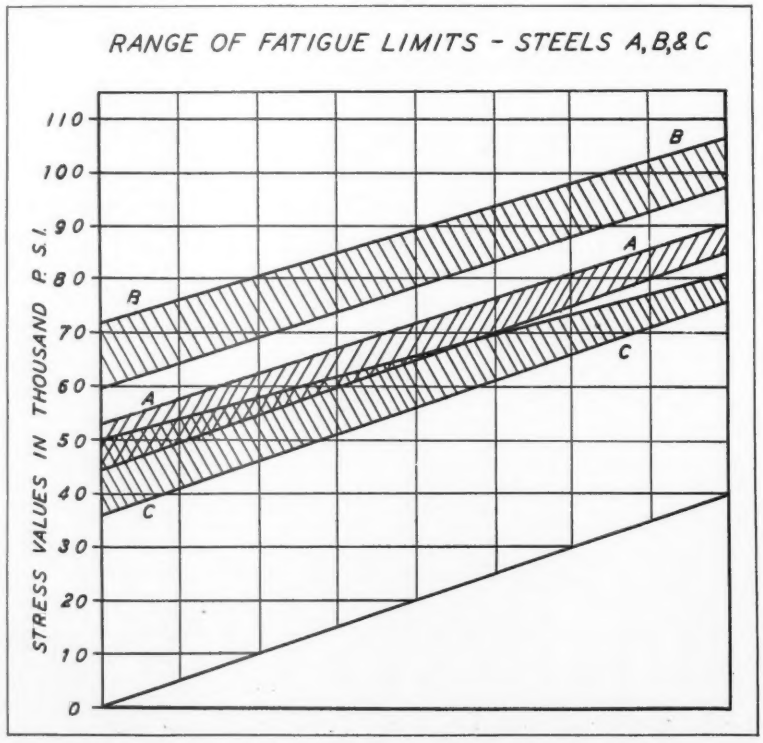



Fig. 15. Fatigue Diagrams showing over-all Range of Limits. Steels A, B, and C. ✦

spring failures. By surface conditions is meant the appearance of the surface of a wire after deep etching in hot hydrochloric acid.

✦ ✦ ✦

FIGURE 25 shows some typical surface conditions after deep etching. These are taken at 8X magnification and, although it is difficult to show surface clearly in a photograph, some discussion can be made from them. In Fig. 25A are large pits, probably from the cleaning operation. In B, a slightly different type of pit is found, shallow and without sharp edges. This type traces back to the steel mill and hot rolling. C shows very fine pits which appear almost like roughness. In D are fine scratches probably arising in the wire drawing. E shows a roughness of texture without appreciable pitting.

✦ ✦ ✦

IN photograph F of Figure 25 is shown a good surface, without any apparent defect.

✦ ✦ ✦

ZIMMERLI (10) published an extensive investigation of surface effect, studying artificial scratches of various types made on polished wire specimens. He ran tests in pure torsion, that is, by twisting a straight sample of wire, with zero minimum stress, determining fatigue limit to the nearest 5,000 p. s. i. According to his results, the worst condition due to the artificial scratch lowered the limit by about 20,000 p. s. i. Tests on springs made from a commercial grade of wire of poor quality gave a value about 40,000 lower than that for polished wire, and 20,000 lower than that for the worst imposed scratch, although the surface scratches of the commercial wire were neither so sharp nor so deep as those made artificially. The conclusion is that the lower endurance limit found with springs is not due entirely to the presence of surface scratches.

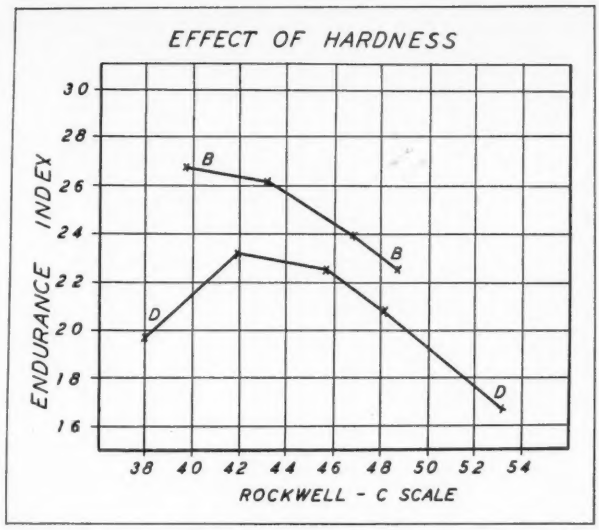



Fig. 16. Influence of Hardness Due to Heat Treatment on Fatigue Value. Steels B and D.

✦ ✦ ✦

REPRESENTATIVE photographs of the steels on which we are now reporting are shown in Figures 26, 27, and 28 for steels A, B, and C, respectively. Comparison of these photographs shows that steel B has the best surface appearance, steel C somewhat inferior, and steel A the poorest. The surface of steel A contains a number of so-called hairline seams, and is generally not so smooth as B and C. Steel B exhibits excellent surface, and steel C, while approaching B in smoothness, contains some very shallow irregularities.

✦ ✦ ✦

IN the light of surface characteristics of these steels, it would be generally predicted that B would be best in fatigue, C second, and A third. The results shown in Figure 15, however, do not bear this out, unless it be assumed that the grain size influence has submerged any effect surface may have. There seems to be considerable evidence in addition to this that surface does not play the important part in spring failures which has been previously ascribed to it. No strict comparison can be drawn regarding surface alone in this instance because of other factors. Nevertheless, there is an indication that surface condition has not affected steel A seriously.

✦ ✦ ✦

## Decarburization

DECARBURIZATION is another defect popularly blamed for many spring failures. **Weibel** (11) reports tests on #4 heat treated wire of .65% carbon, with Rockwell C 42.2. He found decarburization to a depth of about .0005". Tests after grinding to .221" diameter with a #60 grit

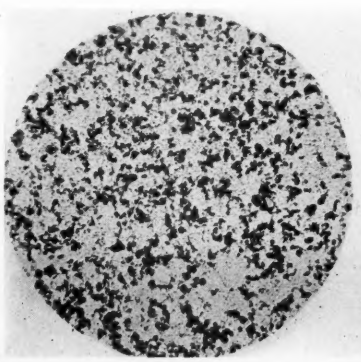


Fig. 17. Austenitic Grain Size, Steel A. 100X.

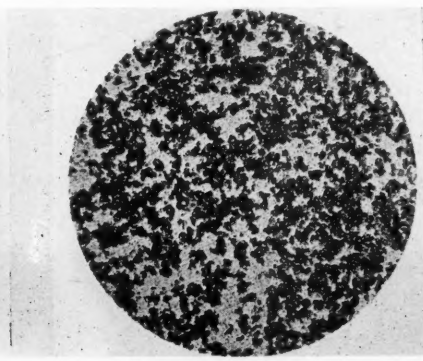


Fig. 18. Austenitic Grain Size, Steel B. 100X.

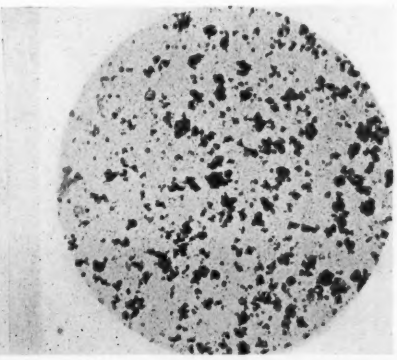


Fig. 19. Austenitic Grain Size, Steel C. 100X.

wheel showed an increase of 21% in bending endurance limit over the as-received material, while in torsion a slight decrease in endurance limit was found. The possibility is offered that the removal of decarburized material has been offset by the scratches left by grinding, circumferential scratches in this case.

✦ ✦ ✦

IN the present investigations, no decarburization was found in representative samples of the steels tested.

✦ ✦ ✦

## Summary

SUMMATION of the considerations given in the foregoing pages supports the following conclusions:

1. True evaluation of the working stresses is the predominating explanation of spring failures.
2. Dynamic conditions may give rise to greatly increased working stresses.
3. Endurance limit of spring materials depends on the class of material in question.
4. Endurance limit of a commercial heat treated wire in helical springs is markedly influenced by the hardness produced in heat treatment, decreasing as the hardness increases from a certain optimum value.
5. Grain size is an important factor in the value of endurance limit, coarser grain definitely giving lower value.
6. There is sufficient evidence to cast doubt on the conception that surface conditions found after deep etching and under magnification affect fatigue adversely.

Fig. 20. Fracture of Square Wire Springs. Mag. 3X. ✦ ✦ ✦

Fig. 21. Seam Found in Spring. Mag. 2X.

Fig. 22. Typical Fatigue Fracture of Oil Tempered Wire. ✦ ✦

Fig. 23. Fatigue Fracture of Hard Drawn Wire. ✦ ✦

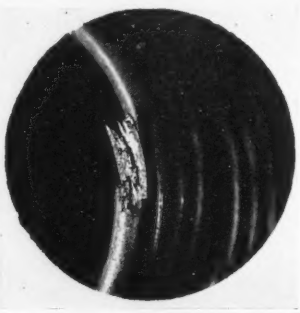


Fig. 24. Fatigue Fracture of Tempered Wire Stressed Over Elastic Limit.

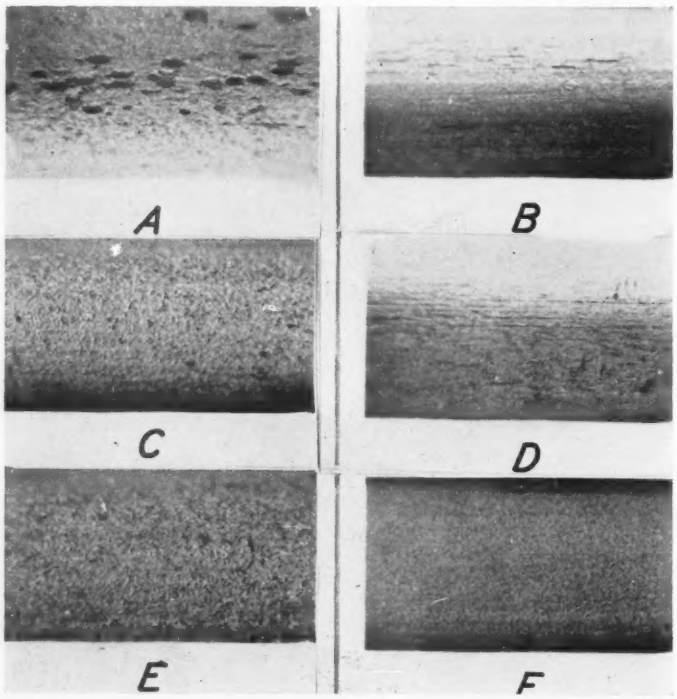



Fig. 25. Examples of Surface. Magnified 8X. Standard Etch. ✦ ✦

## Conclusion

IN conclusion, the author wishes to express his appreciation to the management of his company for their permission to publish this work. There is need of further study to correlate commercial surface conditions with fatigue properties, as well as grain size and decarburization. Some of these points we are planning to cover in the future, and it is hoped that other investigators will contribute their experiences so that makers and users of springs and spring wires may have definite fatigue information available.

✦ ✦ ✦

## References


1. "Development of a Fatigue Testing Method for Springs and Spring Wires." Rodman R. Tatnall, Wire & Wire Products, Vol. 12, No. 6.
2. "Stresses in Heavy Closely-coiled Helical Springs." A. M. Wahl, A. S. M. E. Vol. 51, part 1, 1929.
3. "Why Did That Spring Break?"

E. E. Thum, Metal Progress, March 1931.

4. "Notes on Valve Spring Surge." W. T. Donkin & H. H. Clark, S.A.E. Journal, June, 1927.
5. "Fatigue of Metals." H. F. Moore & J. B. Kommers, McGraw-Hill, 1927.
6. "Effect of Heat Treatment on Fatigue Strength of Steel." E. P. & B. H. Stenger, Trans. A.S.S.T. Vol. 1, 1921.
7. "Wire Drawing and the Cold Working of Steel." A. T. Adam, H. F. & G. Witherby, London, 2nd ed. 1936.
8. "Plastic Deformation in Wire Drawing." B. L. McCarthy, Wire & Wire Products, Vol. 11, No. 10.
9. "Austenitic Grain Size in Steel." E. C. Bain & J. R. Vilella, A.S.M. Handbook, 1936 ed. pp 592-3.
10. "Effect of Longitudinal Scratches on the Endurance Limit in Torsion of Spring Wire." F. P. Zimmerli, Abs. Wire & Wire Products, Vol. 12, Nos. 3 and 4.
11. "The Correlation of Spring Wire Bending and Torsion Fatigue Tests." E. E. Weibel, Wire & Wire Products, Dec. 1935.

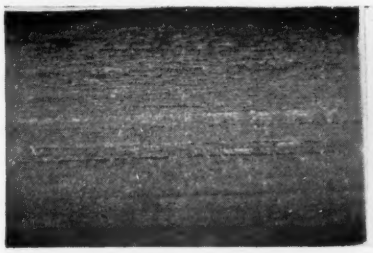


Fig. 26. Surface of Steel A After Acid Etch. Mag. 8X

Fig. 27. Surface of Steel B.

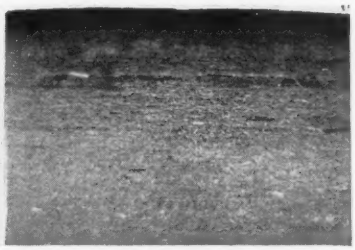
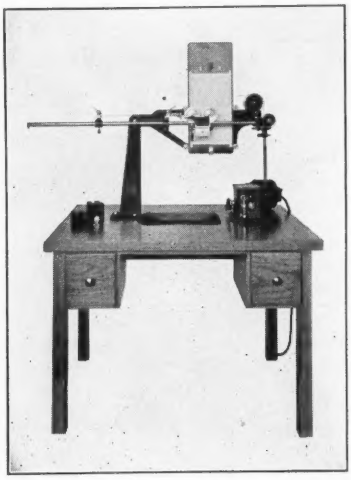
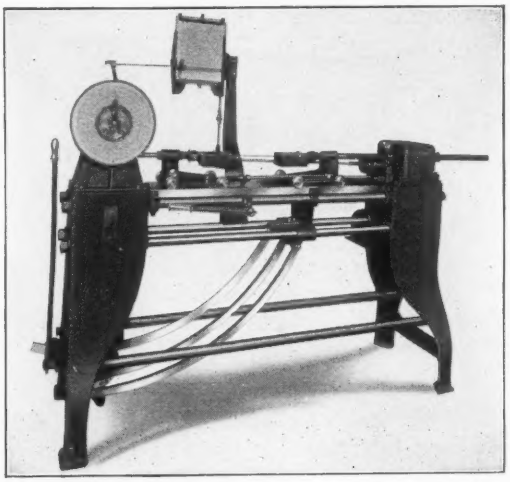


Fig. 28. Surface of Steel C.

SCOTT TESTERS



Model IP-2
Maximum capacity
2 pounds



Model Q-5
Maximum capacity
2000 pounds

AUTOGRAPHIC recording tensile testing machines built on either the constant specimen rate of load or constant speed of pull principles. Made in a wide range of models and capacities with high and low stretch magnification recorders - for Wire, Sheet Metals, Rubber, Textiles, Paper, etc.

May we have your specifications?

HENRY L. SCOTT CO.

P. O. BOX 963 PROVIDENCE, R. I.

# The Manufacture of Fourdrinier Wires

By Hugh E. Brown

Director of Research, The W. S. Tyler Company, Cleveland, Ohio

**An analysis of the manufacturing processes necessary to produce satisfactory Fourdrinier and weaving wires. A market for large tonnages of these materials is available and wire manufacturers are urged to cooperate in new developments along this line.**

THE Fourdrinier Machine used in making paper, performs the function of dewatering the pulp and water mixture in a continuous manner, changing this from a liquid state to a solid sheet of wet pulp.

✦ ✦ ✦

THE Fourdrinier wire is an endless belt of fine mesh used as the conveying medium during this dewatering operation. The liquid pulp is delivered onto the Fourdrinier wire at the wet end of the machine and is carried by it over table rolls and over suction boxes where a vacuum is applied to the under side of the wire. At the far end of the machine the pulp is removed and carried by a felt belt through presses and finally through drying rolls to become the finished paper. The Fourdrinier wire returns under the machine over tightening rolls and is cleaned by water showers before it again receives the pulp.

✦ ✦ ✦

FIGURE 1 shows the Fourdrinier Machine, including the operation from the point where the wet pulp comes onto the Fourdrinier wire through the press and drying rolls and the roll-up equipment at the far end.

✦ ✦ ✦

FIGURE 2 is a closer view of the Fourdrinier wire and particularly shows the wet end of the machine.

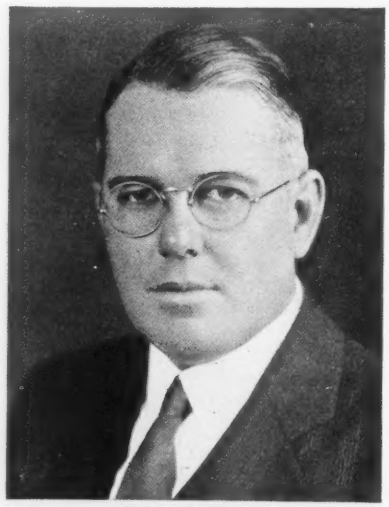
✦ ✦ ✦

FIGURE 3 is another view of the Fourdrinier Machine looking down on the wire.

✦ ✦ ✦

FIGURE 4 is a view showing the men about to install a Fourdrinier wire on the machine.

THE wires are driven at speeds of from 200 to 1550 feet per minute and are supplied in meshes from 40 to 90 to the lineal inch according to the grade of paper made on them. High speed and coarse meshes are used on low grade papers while lower speeds and finer meshes are run on the better papers. For example, newsprint paper is made on 60 to 65 mesh running at around 1000 feet per minute while bond or book paper is produced on 70, 75, or 80 mesh at speeds ranging from 300 to 500 feet per minute.



HUGH E. BROWN

Born—Madison, Wisconsin. Studied at Case School of Applied Science, 1911-1913. Laboratory Assistant, W. S. Tyler Company, 1914. World War (112th Engineers) 1917-1919. Sales Engineer, W. S. Tyler Company, 1919-1926. In charge of Laboratory, 1926-1935. At present, Director of Research, W. S. Tyler Company, Cleveland, Ohio. Member: American Society for Metals; American Institute of Mining & Metallurgical Engineers; Wire Association.

THE size of the wire is determined by the Fourdrinier Machine some of these wires being over 300 inches in width and 100 feet or more in length.

✦ ✦ ✦

MANUFACTURING involves the prepartion of the wire from which to weave the Fourdrinier; the weaving operation; seaming, or fastening the ends together to effect an endless belt; testing and inspection; and research.

✦ ✦ ✦

IN selecting the metal or metals from which to make the Fourdrinier wire there are a great many factors to be recognized and dealt with. The wire must have:

1. **Tensile strength enough to stand the tension of the drive and the weight caused by the load of wet pulp which it carries.**
2. **Ductility to stand the flexing as the wire runs under tension over rolls at high speed. This must be under control as too much stretch cannot be tolerated.**
3. **Resistance to fatigue as cold working too rapidly will cause premature failure of the wire.**
4. **Resistance to abrasion, because of the wear on the suction box covers and abrasive fillers sometimes used in the pulp.**
5. **Resistance to corrosion.**

✦ ✦ ✦

WHEN the materials available are checked against these requirements we find but few left for the construction of these wires. Fourdriniers today are made mostly from brasses and bronzes.

✦ ✦ ✦

## Wire Drawing

IN drawing the wire down from rod size to the fine strands for weaving, lies one of the most critical parts of the manufacturing process as the properties of the metal are built up during this operation. Weaving wire, having smooth surface and true diameter as to size and shape, is an essential as the

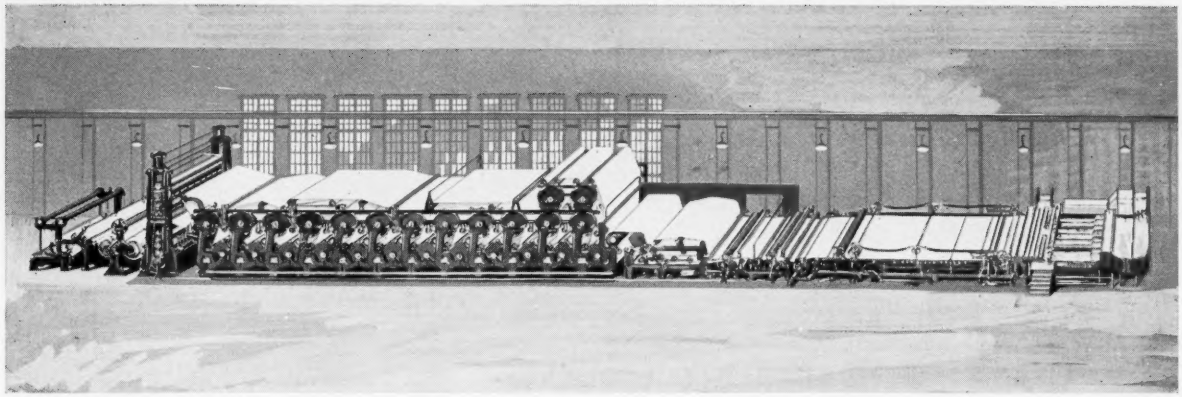


Figure 1.

loom action is influenced by these characteristics. The alternate drawing and annealing operations, when properly scheduled, produce wire of correct physical properties and with the improvements that have taken place in machinery and dies for drawing wire, it is possible to very accurately control the product as it comes from the wire drawing department. Bright annealing equipment, in which an atmosphere of gas protects the wire surface during the annealing operations, has resulted in much improvement as the wire emerging from this furnace has the original die finish and is not subjected to any pickling or other drastic handling after the annealing operation. These furnaces also lend themselves readily to the very flexible operation which is necessary in the Fourdrinier manufacture. With equipment of the continuous type, using controlled atmosphere and accurately controlled temperature, the wire can be produced hour after hour with practically no change in its properties.

✦ ✦ ✦

## Testing the Wire

THE testing of fine strands of wire is difficult and takes considerable time under ordinary conditions. This is especially true where routine testing is done in connection with production. As the grain size of the metal has a definite relation to its physical properties, it has been found that control of drawing and annealing can be greatly simplified by the measurement of the grain size under the microscope. On metals of known chemical analysis, standards of grain sizes are set up and readings can be made at all stages of the manufacturing process. The wire while being drawn down to size, the strands in the finished wire mesh, or even the wires in a worn out Fourdrinier returned from service, can be judged by observation under the microscope. In fact, the worn out wire could not be measured in any other way as obviously physical tests made in the ordinary manner on this would be of little use.

✦ ✦ ✦

THIS method makes it possible to duplicate results or to make definite changes in the wire as may be necessary from time to time. It has been found that slight changes in the drawing or annealing schedules result in very noticeable changes in the grain size of these Fourdrinier materials. As the field is so varied in its requirements, the weaves, physical properties of the metals, and even the chemical analysis of them must often be varied to suit specific cases. The present day wire drawing department can do these things because of the flexibility of the equipment and the results can be accurately and quickly checked by the use of the microscope.

✦ ✦ ✦

FIGURE 5 illustrates the relationship between grain size and physical properties in brass wire, the pictures shown representing several steps within the range of properties useful for weaving wire.

✦ ✦ ✦

FIGURE 6 shows the relationship between the grain size and physical properties of phosphor bronze wire.

✦ ✦ ✦

IT is possible to observe changes in the grain size when practically no change can be noted in the physical properties of these metals. That is, as annealing or drawing procedure is changed in the wire drawing and very slight physical changes are affected, very often the grain size changes are quite pronounced so that very fine adjustments may be made and controlled by the use of the microscope.

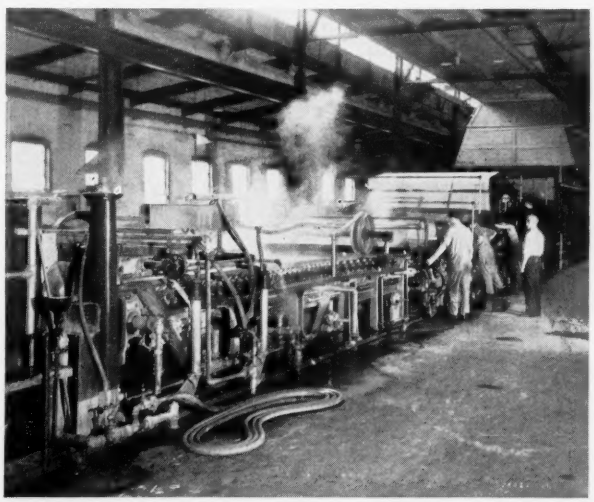


Figure 2.

## Weaving

THE weaving operation is in principle exactly the same as it has always been, the old familiar process of stringing up the warp strands in a fashion so that they can be shed and the shoot strands being shot back and forth by means of the shuttle. Because of the size of the Fourdrinier machine the looms for weaving these wires have naturally grown to considerable proportions and the mechanism has been somewhat complicated so as to produce a smooth and perfect sheet of wire mesh from which to make the Fourdrinier wire.

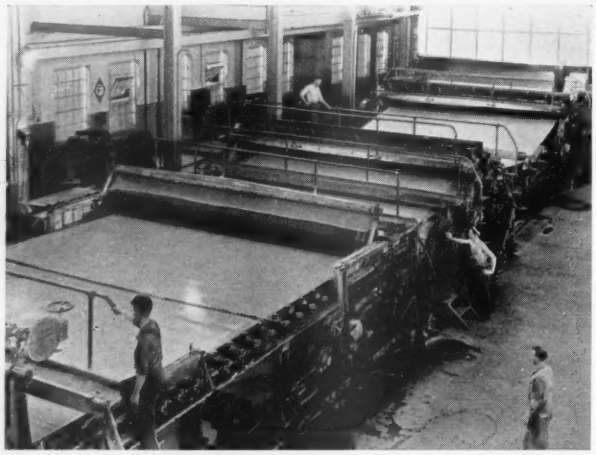


Figure 3.

✦ ✦ ✦

FIGURE 7 shows a view of a Fourdrinier loom which is capable of weaving in widths up to 13 feet.

✦ ✦ ✦

FIGURE 8 is a still larger loom, weaving up to a maximum width of 28 feet.

✦ ✦ ✦

THE ordinary Fourdrinier wire is made in the regular weave where each wire goes over one and under the next in the conventional manner. The size of the warp wire, the mesh count in the warp, the drive up, or count in the shoot wires, as well as the shoot wire diameter, are all selected so as to produce a Fourdrinier having proper characteristics for the particular paper to be made, at the same time providing the highest percentage of air space, or drainage, as consistent with strength and other requirements. These features, as well as the physical properties of the wires themselves, are all a function of the smoothness of the finished wire. The Fourdrinier must have a smooth surface so that it will produce unmarked paper.

TWILLED weave is made by a change in the heddle system of the loom so that each wire goes over two and under two. In Semi-twilled weave each wire goes under two and over one.

✦ ✦ ✦

FIGURE 9 illustrates a plain weave mesh such as used in Fourdrinier work.

✦ ✦ ✦

FIGURE 10 shows a full-twilled weave.

✦ ✦ ✦

FIGURE 11 shows the semi-twilled weave.

✦ ✦ ✦

## Seams

AFTER the wire mesh has been woven to the proper length for making up a certain Fourdrinier wire, it is cut from the loom and the two ends are fastened together so as to make an endless belt. Many ways of doing this have been devised and considerable work is still being done in finding improved ways of attaching these ends or forming the seams. The seam must have proper drainage conditions so as not to weaken the paper sheet. A bad seam can cause a great deal of trouble in the paper mill. It may result in jerking of the wire as it passes over the suction boxes, it may cause the paper sheet to actually break, or it is possible for it to leave a mark every time it comes around in the dewatering operation.

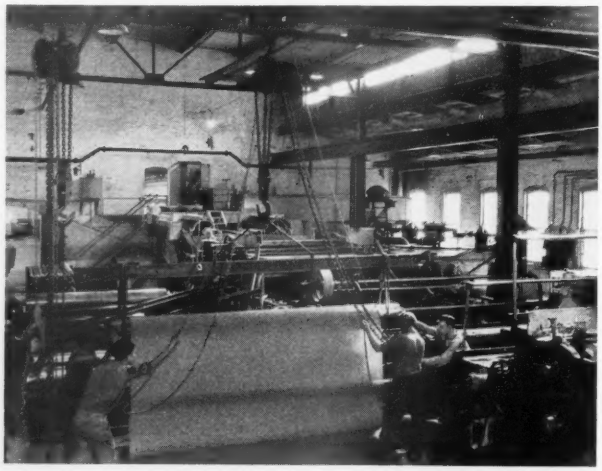


Figure 4.

✦ ✦ ✦

FIGURE 12 is a view of a regular sewed seam. This is one of the original means used for fastening together the ends of a Fourdrinier wire and it is still used very largely although some of the newer types of seams are gradually replacing it.

✦ ✦ ✦

FIGURE 13 is also a sewed seam but in this case the last wires were brazed in place and the sewing put in the first row of holes on each side of the seam. This is also used quite successfully for some applications.

✦ ✦ ✦

FIGURE 14 is a full brazed seam with no sewing, a type of seam that is rather new but is gaining popularity rapidly.

✦ ✦ ✦

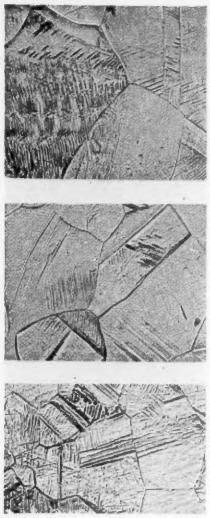
WITH the completion of the seam, final inspection of the wire includes running it on a set of rolls to make sure that it runs true and finally the wire is rolled up on three rollers and packed in a rugged box for shipment to the paper mill.

✦ ✦ ✦

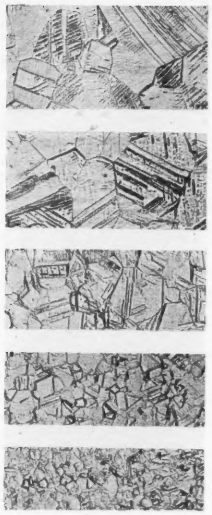
## Laboratory Control

THROUGH the entire manufacture of Four-

Figure 5. Brass .010″ Diameter

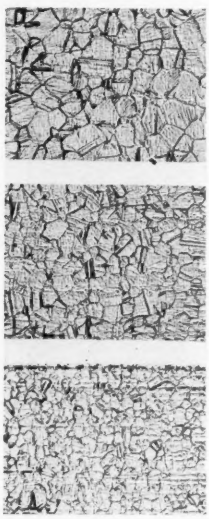


| Tensile Pounds Per Square Inch | Elongation Per Cent |
|---|---|
| 38,100 | 14 |
| 40,200 | 15 |
| 41,400 | 15 |

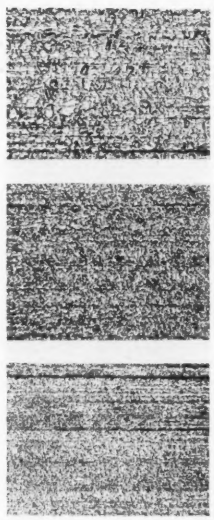


| Tensile Pounds Per Square Inch | Elongation Per Cent |
|---|---|
| 47,800 | 21 |
| 49,700 | 23 |
| 50,900 | 30 |
| 54,200 | 37 |
| 57,200 | 38 |

Figure 6. Phosphor Bronze .010″ Diameter.



| Tensile Pounds Per Square Inch | Elongation Per Cent |
|---|---|
| 57,200 | 30 |
| 62,400 | 27 |
| 63,600 | 26 |



| Tensile Pounds Per Square Inch | Elongation Per Cent |
|---|---|
| 66,700 | 23 |
| 73,200 | 21 |
| 76,300 | 20 |

drinier wires laboratory control is essential. The drawing, annealing, and weaving operations are checked at frequent intervals in order to make sure that no variation is creeping into the process. The raw materials used are checked chemically and physically before entering the production departments and in addition to this the laboratory must continually conduct research work looking for new materials, better ways of handling them, and studying the results of Fourdriniers in the field.

IT is generally admitted that laboratory tests cannot be taken too seriously. However, considerable valuable information may be obtained if the tests are set up so as to come as near as possible to actual conditions. By means of laboratory tests on corrosion it is possible to find out what particular metals show best resistance to certain specified solutions. In this work it is customary to secure some of the actual solution from the paper mill and the samples of mesh made from various metals are partially submerged in this solution and left there for a long enough period of time to note the results. At the conclusion of a test like this, certain metals are definitely eliminated, others appear to be absolutely safe, and some of course are in question. By weighing the samples before the test and again at the conclusion of it and noting the loss of weight, a fair idea can be obtained of the attack of this solution.

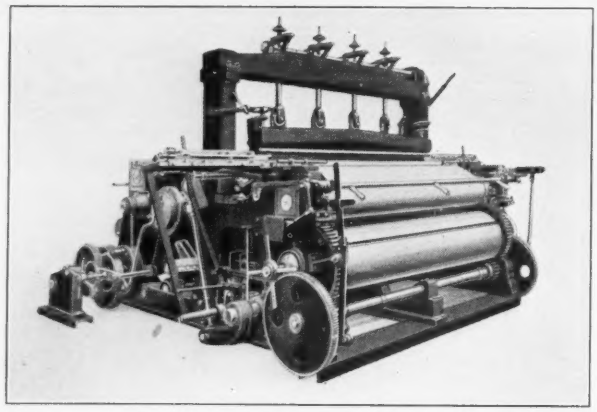


Figure 7.

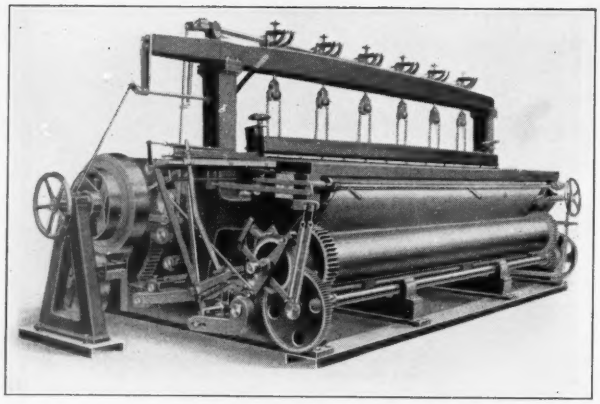


Figure 8.

Acknowledgement: Pictures used in Figures 7 and 8 through courtesy of Marburg Brothers.

FIGURE 15 shows the results of a corrosion test made in this fashion using a solution containing considerable chlorine bleach. By observing the right hand column of the tabluation, it will be noted that the KA2 stainless steel shows the least attack in this particular solution having lost but 2% in thirty-eight days of test, while a mixture of phosphor bronze warp and brass shoot, shows the greatest loss, namely 17%. This data would also indicate that monel and lower grade stainless steel are on about a par but that pure nickel would be unsatisfactory for the service.

✦ ✦ ✦

## Flexing Tests

INASMUCH as Fourdrinier wire is so severely flexed in service, it has been found very helpful to make laboratory tests in this regard. These have indicated that very slight alterations in the properties of the Fourdrinier wire composition, in the diameters of the wires, or the count of the mesh will make very great differences in the ability of this wire to stand flexing under tension. Accelerated tests on flexing have so far been quite successful in pointing the way as to which metals will best

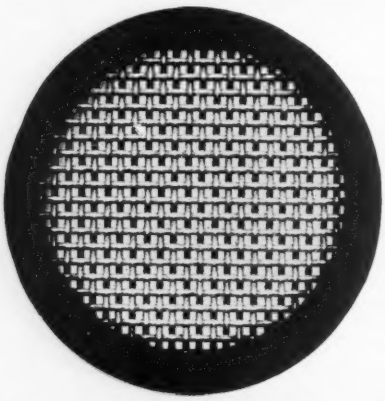


Figure 9.

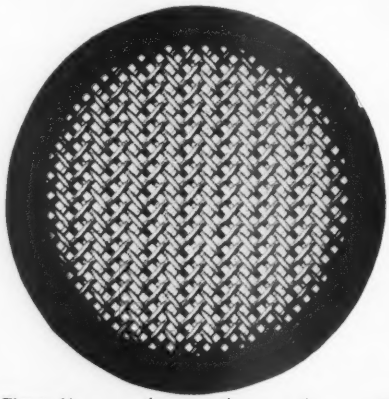


Figure 10.

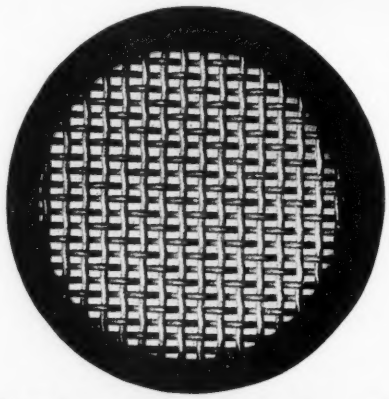


Figure 11.

Figure 12.

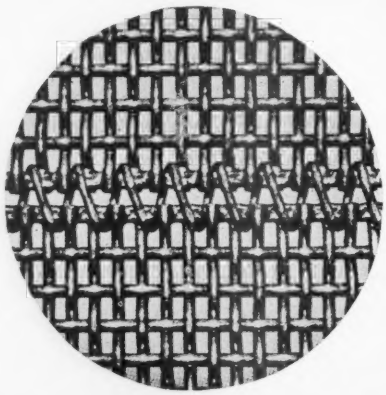


Figure 13.

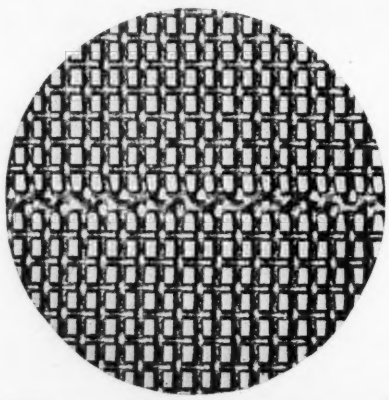


Figure 14.

stand this service and they are instrumental in choosing the right temper of the warp and shoot wires for best results.

✦ ✦ ✦

FIGURE 16 shows a machine devised for making these accelerated flexing tests. Strips of wire mesh are placed in the machine so as to be under a definite tension. A carriage provided with three rollers moves back and forth so that the strips of cloth are given a severe flexing action which is recorded by the number of bends given the strips. As the mounting of the samples is uniform, each strip is subjected to exactly the same test and a direct comparison can be made. While it is not possible to calibrate this machine in terms of days of life of Fourdrinier wires or anything of that sort, nevertheless, the results are relative and two different metals or two different tempers of the same metal can be directly compared.

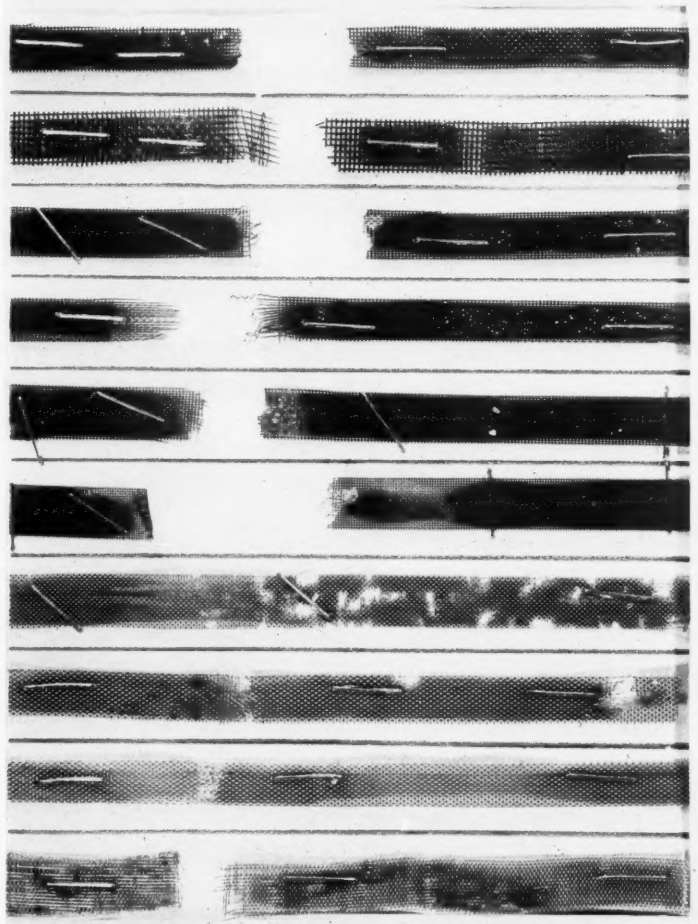
✦ ✦ ✦

FIGURE 17 shows the data taken from a test on this machine. In the column headed Bends is found the relationship of some of the well-known metals. It will be noted that bronze #5 took 55,233 bends before it cracked, while other metals were able to stand much less before failure.

✦ ✦ ✦

FIGURE 18 shows another machine designed to flex wire cloth belts. The top pulley can be changed to any size, the speed of the belt can be varied, the tension on the belt is constant for any particular test but can be very easily changed

CORROSION TEST ON VARIOUS METALS IN BLEACH SOLUTION




| METAL | ORIGINAL WEIGHT | FINAL WEIGHT | LOSS % |
|---|---|---|---|
| BRASS | 2.28 GM. | 1.98 GM. | 13 |
| COMMON BRONZE | 2.77 | 2.50 | 10 |
| PHOSPHOR BRONZE | 2.54 | 2.15 | 15 |
| PHOSPHOR BRONZE WARP BRASS SHOOT | 2.35 | 1.95 | 17 |
| COPPER | 2.24 | 1.99 | 11 |
| EVERDUR | 1.90 | 1.63 | 14 |
| NICKEL | 1.92 | 1.66 | 14 |
| MONEL | 2.41 | 2.22 | 8 |
| STAINLESS STEEL KA-2 | 1.95 | 1.91 | 2 |
| STAINLESS STEEL R.A. (NEVASTAIN) | 2.00 | 1.83 | 9 |

THESE SAMPLES WERE IN THE SOLUTION FOR 38 DAYS.

Figure 15. ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦ ✦

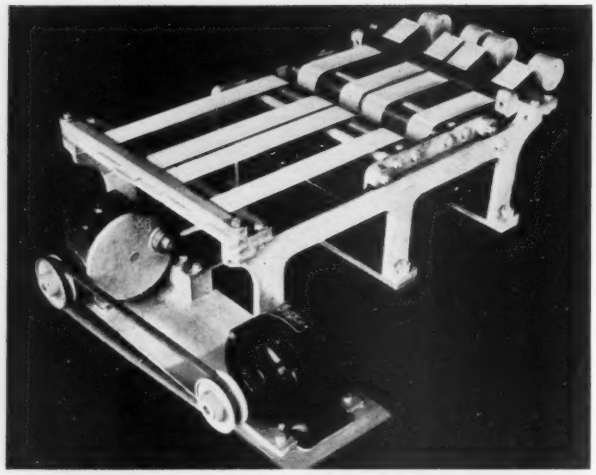


Figure 16.

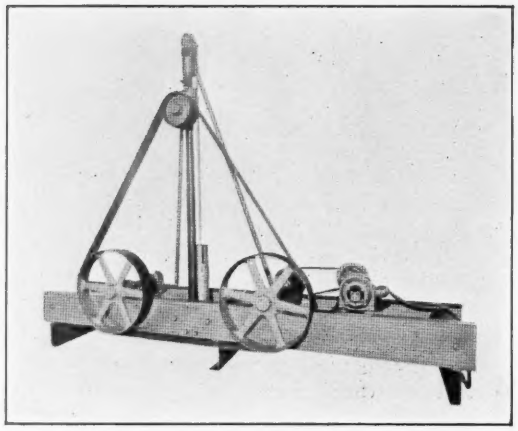


Figure 18.

and in this way a long time test is conducted. The data collected on this machine is very interesting but of course it is a slow process as a Fourdrinier made of proper metal and having proper characteristics will run for probably from three to five thousand hours before failing. The tests on these two flexing machines are very valuable in designing Fourdrinier wires and they are especially important when it comes to investigating new metals and alloys in order to determine whether or not they have Fourdrinier possibilities. If a metal will stand the flexing test made on these two machines and if it is also properly resistant to corrosion, the indications are that it will be well worth the cost of stringing up a small warp on a loom and going far enough to get a field test on a Fourdrinier wire made from that metal. Field tests are costly to the manufacturer and to the paper mill. The idea involved in testing in the laboratory is to prevent making the field tests unless there is a very good indication of success. Fortunately the paper mill operators are as much interested in improving the Fourdrinier wire as is the manufacturer and in no industry is there a better cooperative spirit than is found in these mills.

✦ ✦ ✦

YOU of the metal industry are urged to investigate more carefully the alloys and metals available and possibly work out new and better ones in the future which may assist in producing a better Fourdrinier wire. There is a market for large tonnages of these materials and you will find the manufacturers of these wires more than willing to cooperate with you in establishing the feasibility of any new development along this line.

FIG. 17. BENDING TEST ON 60 MESH WIRE
Various Metals

| Metal | Mesh | Warp Wire | Shoot Wire | Tensile ½" Strip Pounds | Bends | Elongation Percent |
|---|---|---|---|---|---|---|
| High Nickel Alloy | 60 | .009 | .009 | 101 | 11,366 | 18.0 |
| Brass | 60 | .009 | .010 | 64 | 19,070 | 19.0 |
| Phosphor Bronze No. 3 | 60 | .009 | .010 | 66 | 26,995 | 20.0 |
| Phosphor Bronze No. 4 | 60 | .009 | .010 | 96 | 34,987 | 28.0 |
| Bronze No. 5 | 60 | .009 | .009 | 99 | 55,233 | 30.0 |

Bends Made on 1½" Rolls at the Rate of 178 Bends Per Minute.

To Those Registering and Attending the Wire Association Meetings
THERE WILL BE A REGISTRATION FEE OF $5.00
Admission will be by Badge Only

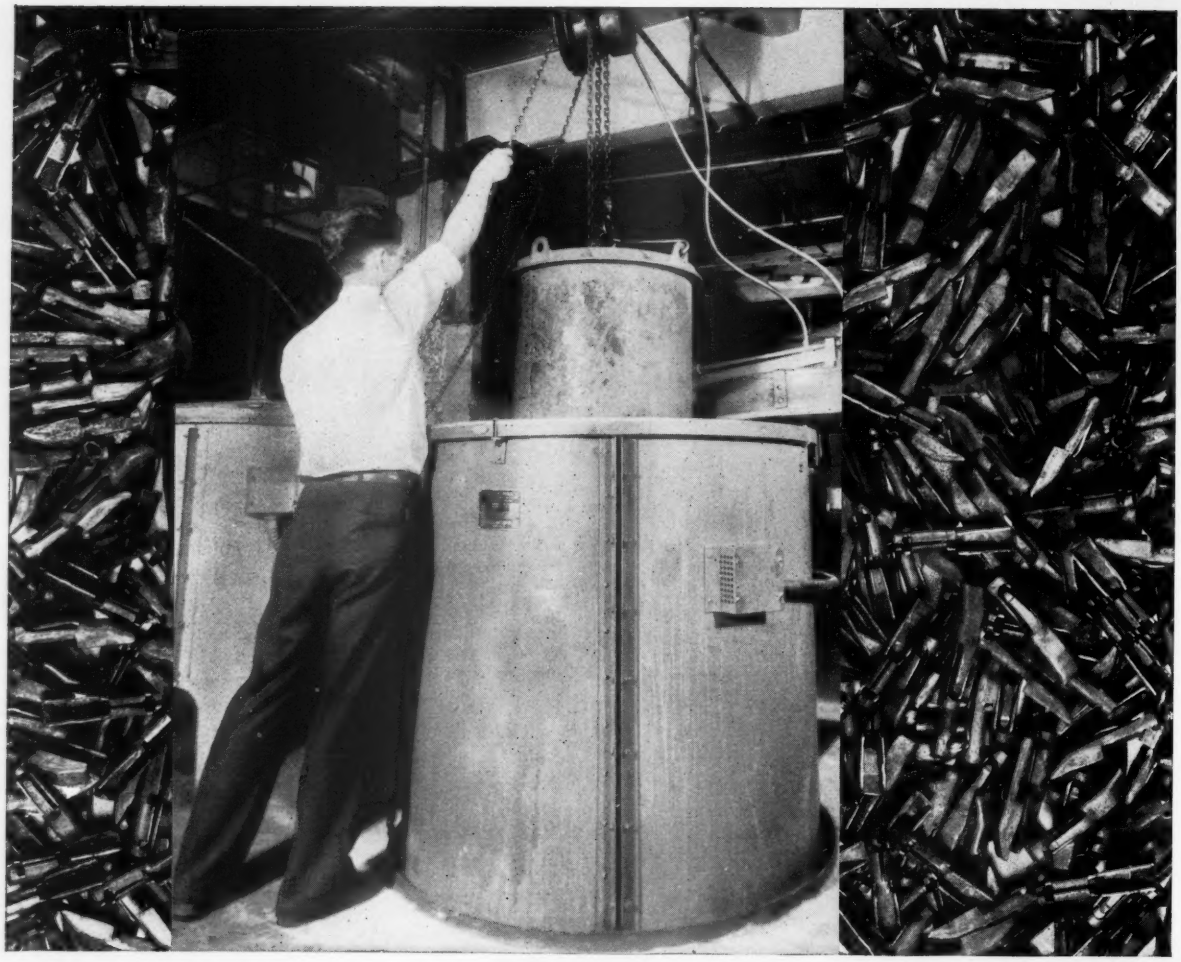
To Those Registering and Attending the Meetings,
Stenographic Copies of the Discussions will be Available Free
To All Others, $5.00 per Copy

# WIRE BY *Laclede*

## MEANS WIRE

- **Processed to your individual specifications.**
- **Precision controlled during manufacture from raw materials to finished wire.**
- **Accurate in size.**
- **Uniform in temper.**
- **Consistent in finish.**

# LACLEDE
## STEEL COMPANY
**ST. LOUIS, MO.**



# Uniformity? O.K.

## Parts are treated in HOMO FURNACES

To get the highly uniform heat they need for identical hardening, these little "contact clips" of cadmium-plated beryllium copper go into one of International Business Machines' Homo Furnaces. Fifty thousand at a time, they are put into a pre-heated Homo. Its blast of electrically-heated air whisks them up to 530° F., and holds them there for a 45-minute soak.

Worked out in IBM's first Homo Furnace, this operation is now carried out in a new and larger Homo of the same type. To the original Homo principle, this Furnace adds refined design, improved materials and the latest developments in control appliances. It is one of a complete line, made in various models and types, from which a furnace can be selected for most efficient operation at 1400° F. or below on either non-ferrous or ferrous parts—open loads, medium ones, or dense.

J-T-625(6)

*See Our Exhibit at the National Metal Exposition*

**LEEDS & NORTHRUP COMPANY, 4974 STENTON AVE., PHILA. PA.**

**LEEDS & NORTHRUP**

**MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES**

# Developments In Cold Heading At General Electric

By A. R. Ryan,
Industrial Heating Engineer, General Electric Co.,
Schenectady, N. Y.

**It is the purpose of this paper to describe the cold heading section of the screw machine department, located at the Schenectady Works of the General Electric Company, and to point out certain features of the manufacturing process and equipment that undoubtedly will be of interest to persons concerned with cold heading operations.** ✦ ✦ ✦ ✦ ✦

COLD heading in the General Electric Company began quite a number of years ago with the production of brass screws such as those used in house wiring appliances. The production of cold headed products was greatly increased in the early 1920's because of the requirements of radio receiver manufacturing, which necessitated a great number of small and special screws and rivets.

✦ ✦ ✦

MOST of the larger screw and bolt requirements had been met either by purchase from outside vendors or by internal manufacturing with screw machines.

✦ ✦ ✦

THE requirements for special screws and studs for use in a diversity of electrical products, began to tax the capacity of the screw machines and, because of their special nature, they could not readily be obtained from outside vendors. It was then that the lessons learned on cold heading of small parts began to be applied to larger pieces, so that by 1924 an appreciable production of cold headed cap screws, copper studs, and the like had been achieved.

✦ ✦ ✦

THE cold heading department of a plant, such as the Schenectady Works, is essentially a jobbing shop, as various departments send in requests for standard or special parts, in lots ranging from a dozen or two to a million or more of identical parts.

✦ ✦ ✦

FIGURE I illustrates the variety manufactured in 1936. Such a department is a necessity to a large modern plant as it can produce special parts rapidly, thereby making facilitating shipment of electrical equipment. Also, it gives the engineer who designs a motor, refrigerator, or similar piece of equipment direct control over the quality of screw or stud he wishes to use. Experience has proved to the design engineers that a stress relief anneal is very desirable on cold headed cap screws that are to be used on machines that may be subject to shock stresses or where power wrenches are used for assembly. Magnetic contractors are a good example of this type of machine. Another example is the sealed-in refrigerator mechanism, in which a sheared cap screw head would ruin the mechanism. Such machines, which must operate for years without attention, require the use of stress relief annealed cap screws.

A. R. RYAN

The author was graduated from Washington University with the degree of Bachelor of Science in Electrical Engineering in 1927. Since then he has been with the General Electric Company, at Schenectady, N. Y. He spent a year and a half on the student "Test" course and the last eight and one-half years as an application engineer in the Industrial Heating Section of the Industrial Department. His work has involved the application of electric furnaces to various heat treating processes and in particular to those applications involving scale-free hardening.

✦ ✦ ✦

IN spite of the fact that a cold heading and screw machine department is a necessity for the production of special parts, it is, of course, necessary that the cost of producing screws and studs be comparable to market prices. The early work on cold heading indicated that, where applicable, it usually was superior to screw machine methods. Cold heading and thread rolling was not only rapid and produced a good product but also effected an appreciable saving in material and labor.

✦ ✦ ✦

NUMEROUS studies have been made to determine the overall savings which could be made by utilizing cold heading and thread rolling in place of screw machine methods. Figures 2, 3, and 4 illustrate a few of these studies and indicate the reason for the application of cold heading and thread rolling wherever possible. Naturally, machines can not always be kept busy on special parts, hence it was a logical development to produce as many of the standard cap screws required by the works as the capacity of the equipment would allow.

## Illustrations of Economies to be Obtained by Changing from Automatic Screw Machine to Cold Heading Process.

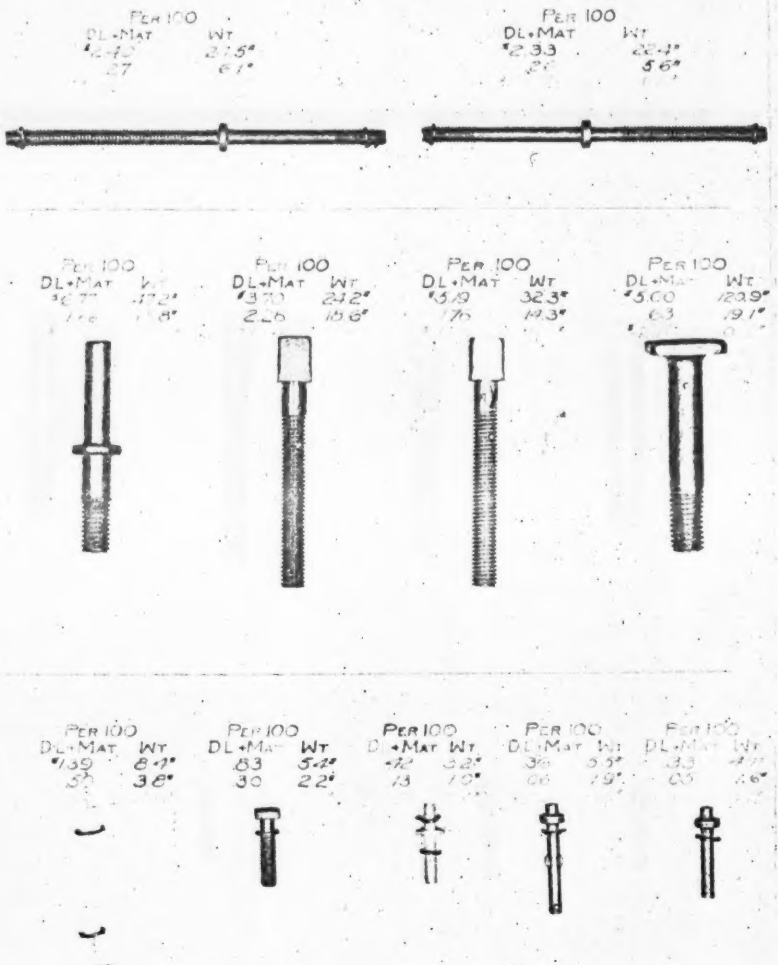
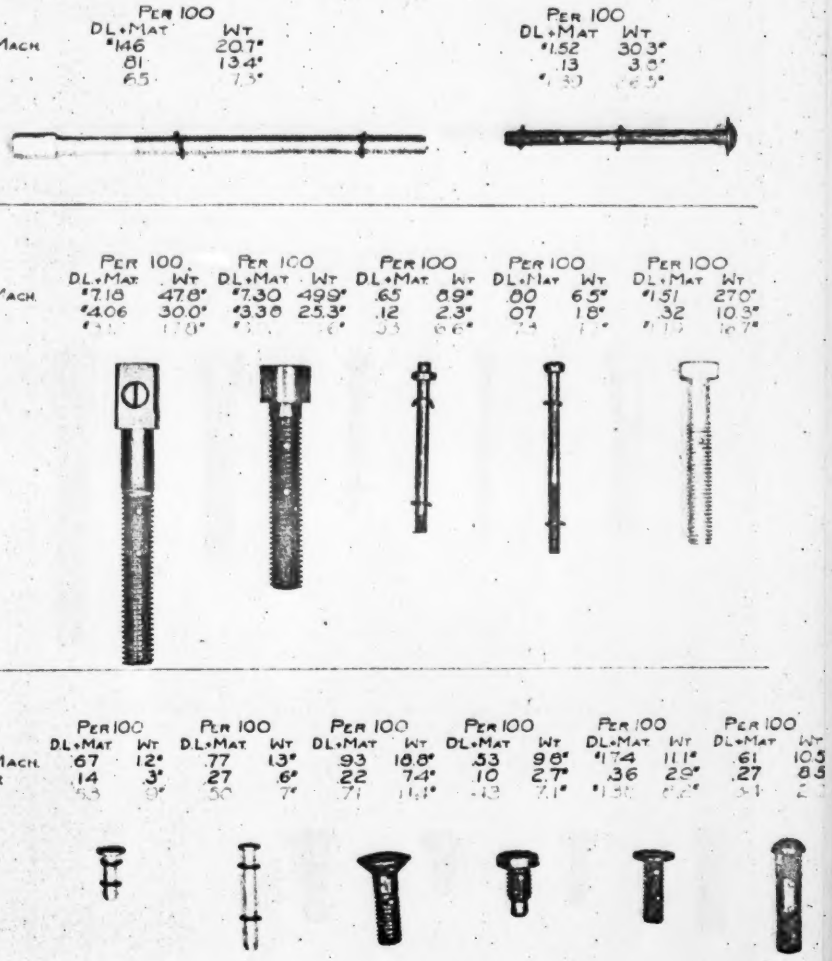


Figure 2

## Illustrations of Economies to be Obtained by Changing from Automatic Screw Machine to Cold Heading Process.

| | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt |
|---|---|---|---|---|---|---|---|---|---|---|
| Screw Mach. | $1.46 | 20.7# | | | $7.18 | 47.8# | $7.30 | 49.9# | $1.51 | 27.0# |
| Header | .81 | 13.4# | | | $4.06 | 30.0# | $3.38 | 25.3# | .32 | 10.3# |
| Saving | .65 | 7.3# | | | | | | | | |



| | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt | Per 100 DL+Mat | Per 100 Wt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Screw Mach. | .67 | 12# | .77 | 13# | .93 | 16.8# | .53 | 9.8# | $1.74 | 11.1# | .61 | 10.3 |
| Header | .14 | 3# | .27 | 6# | .22 | 7.4# | .10 | 2.7# | .36 | 2.9# | .27 | 8.3 |
| Saving | .53 | 9# | .50 | 7# | .71 | 11.4# | .43 | 7.1# | $1.38 | 8.2# | .34 | 2 |

Figure 4

## The Present Plant for Cold Heading

FROM the small section used to produce brass screws for house wiring appliances, the cold heading section has grown into a large well-equipped plant. Figure 5 shows the present arrangement of equipment that has been designed to facilitate the flow of materials with a minimum of handling.

✦ ✦ ✦

IN some respects the layout is unique, for example, monorail conveyors are provided to carry coils of wire from storage direct to the unreeling device of each cold heading machine. This not only makes the work easier for the operator, but it also enables heavier coils to be handled, thereby reducing the number of times per day that the machine must be shut down for starting a new wire. With old hand-loading methods coils were limited to 200 pounds, but with the conveyors, coils of 600 pounds can be handled with ease. At present the maximum of weight of coil regularly obtainable is 350 pounds. This weight of coil saves about 15% in operating time over the older 200 pound coils.

✦ ✦ ✦

WHEREVER possible, the machines are equipped with automatic feeding mechanisms so that one operator can easily supervise several machines. This arrangement frees the operator from much manual work and provides him with sufficient free time to inspect the quality of work being produced by each machine.

✦ ✦ ✦

## Machine Grouping

IN order to eliminate excessive handling and to facilitate flow of materials, the machines are divided into two general groups, one for small screws up to $\frac{3}{16}$ inches and another for screws, $\frac{1}{4}$ inch to $\frac{5}{8}$ inch by 6 inches long. In the small screw group, fourteen cold headers are placed in a row. Adjacent to them, but across an aisle, are a row of slotting machines with loading hoppers accessible from the aisle. In another parallel row are a group of thread rolling machines. Two tumbling

**FIGURE 1**
**TABULATION OF 1936 PRODUCTION**

| APPROXIMATE PRODUCTION | |
|---|---|
| **Type of part** | **Number of parts** |
| **Copper rivets** | **222,300** |
| **Brass rivets** | **55,200** |
| **Steel rivets** | **448,700** |
| **Brass screws** | **4,733,900** |
| **Steel screws** | **15,334,100** |
| **Miscellaneous specialties** | **66,247,800** |
| **Total production for ten months of 1936** | **87,042,000** |
| **Estimated total production for 1937** | **125,500,000** |

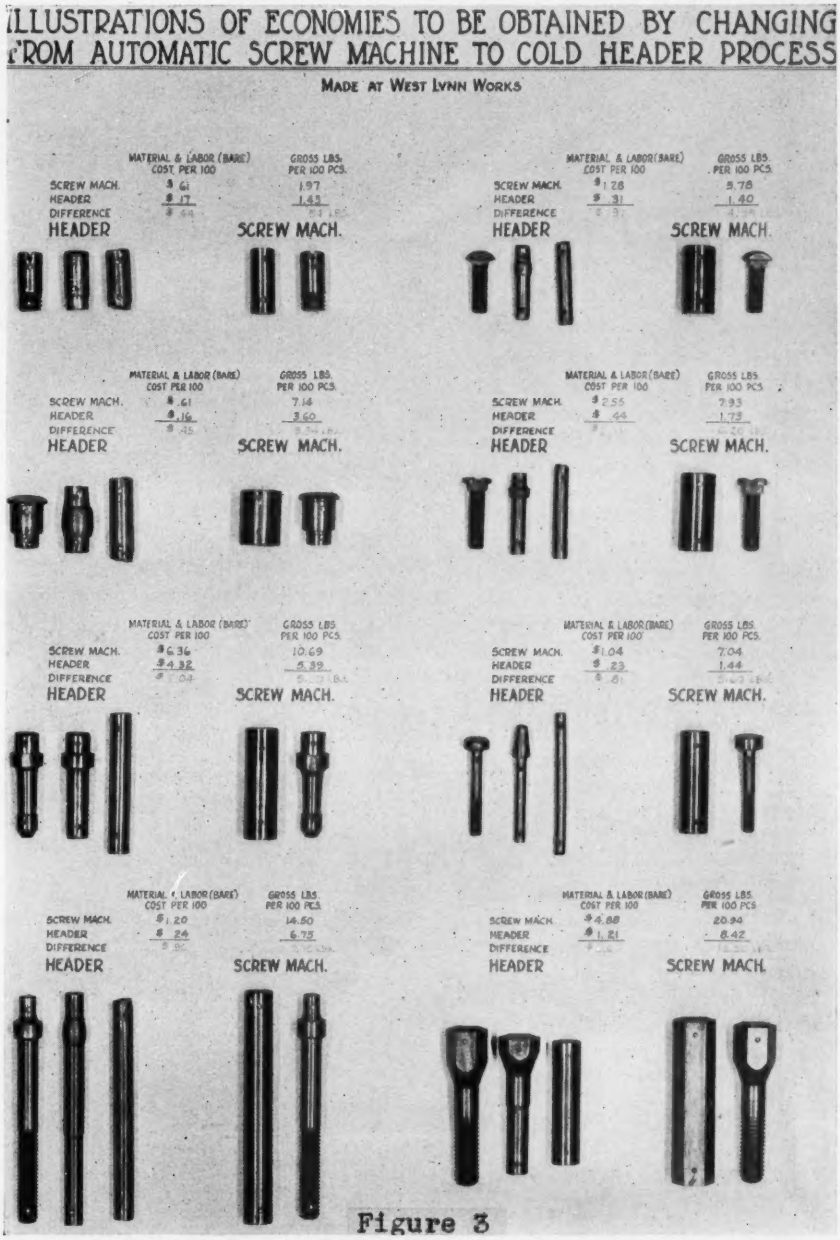

ILLUSTRATIONS OF ECONOMIES TO BE OBTAINED BY CHANGING FROM AUTOMATIC SCREW MACHINE TO COLD HEADER PROCESS
MADE AT WEST LYNN WORKS
MATERIAL & LABOR (BARE) COST PER 100
GROSS LBS. PER 100 PCS.
SCREW MACH.
HEADER
DIFFERENCE
HEADER
SCREW MACH.

Figure 3

barrels are provided for removal of burrs, when necessary. The row of thread rolling machines face on an aisle containing a double-decked gravity conveyor which serves both as storage space and as a means of conveying the finished screws to a conveyorized, alkaline washing and drying machine. The washing machine delivers the washed and dried parts into tote boxes which are then loaded on delivery trucks.

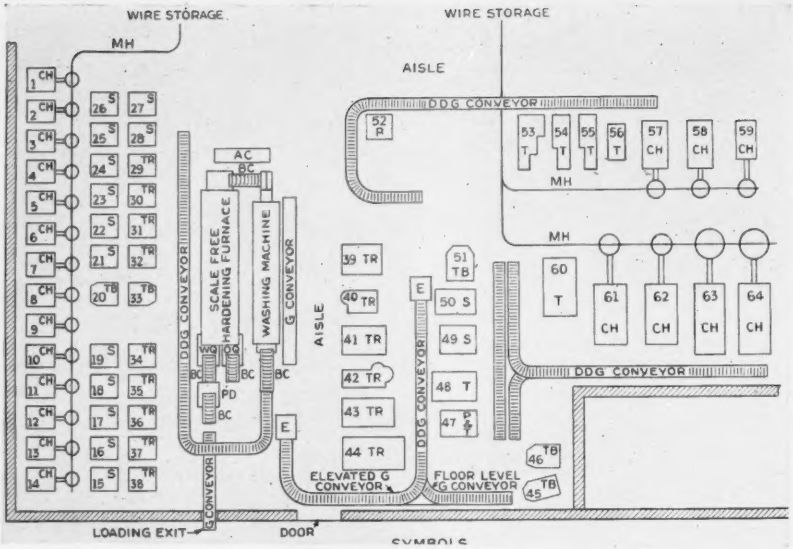



Fig. 5. Cold Heading Department of Schenectady Works.

✦ ✦ ✦

THE section of the plant devoted to the production of larger parts is separated from the small part section by the shipping aisle. The wire for large screws is carried by monorail hoist from storage to the unreeling mechanisms of the seven large cold headers. Double-decked, gravity-type conveyors, transport the cold headed studs from the headers to four large, high-speed trimmers, where the hex head is formed. The same gravity conveyors transport the trimmed blanks to a group of shavers, pointers, and slotters and thence to tumbling barrels for removal of burrs.

✦ ✦ ✦

ANOTHER roller conveyor carries the parts to a line of large thread rolling machines, which deliver the threaded screws into tote boxes directly on the main aisle.

✦ ✦ ✦

## Heat Treating

ALL low-carbon cap screws are given a strain relief anneal so as to prevent failure of the head. Depending upon the size of the screw, this consists of a 20 to 30 minute heating at 600 degrees C in a conveyor-type, scale-free hardening furnace, as shown in figure 6. Before entering the furnace, the screws are dumped, a tote box at a time, into a vibrating loader, which causes them to load uniformly into a cup-type conveyor. This conveyor, in turn, places the screws on the conveyor of the washing and drying machine, which removes all traces of lubricating oil or compound. From the washing machine the screws are automatically loaded into the electrically-heated, conveyor-type, scale-free hardening furnace.

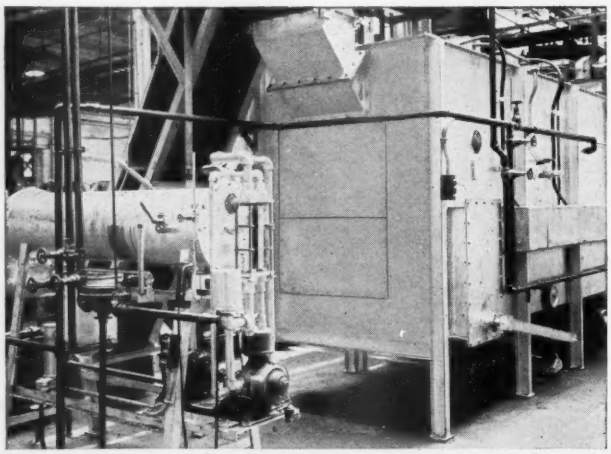


Fig. 6. Charging end of conveyor-type, scale-free hardening furnace.

✦ ✦ ✦

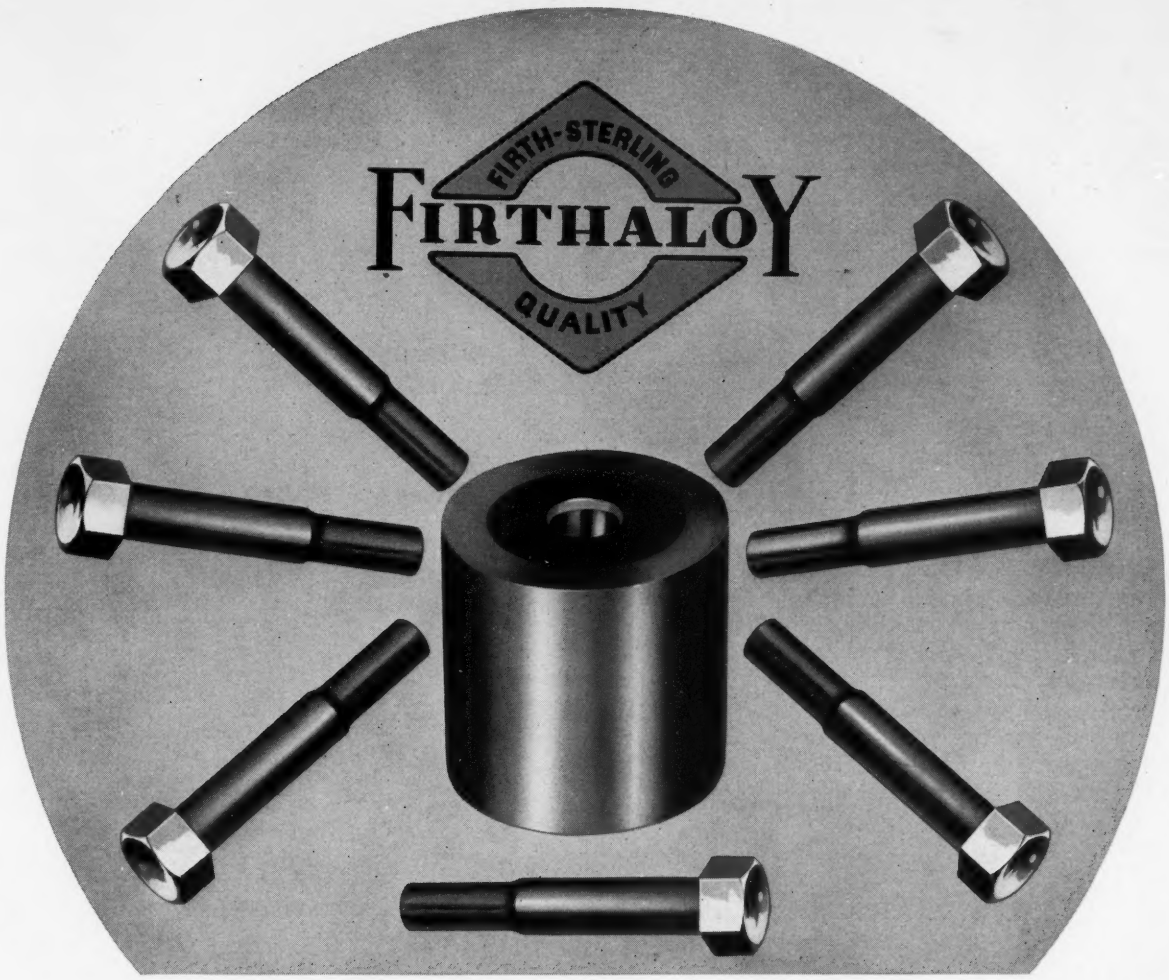
THE furnace consists of a refractory-lined, heat-insulated chamber, enclosed in a welded, gas tight steel casing. It is heated by means of nickel-chromium alloy resistors which are proportioned throughout the length of the furnace in three separate automatically-controlled circuits, one of which accurately controls quenching temperature. The furnace contains a cast, heat-resisting alloy conveyor, which is entirely enclosed in the heating chamber. Material is placed on the furnace conveyor by means of a chute which catches the screws discharged from an elevating conveyor. The washing machine discharges directly onto the elevating conveyor. A seal is provided in the charging chute to prevent escape of protective atmosphere.

✦ ✦ ✦

THE screws that are loaded on the furnace conveyor are heated while being carried the length of the furnace and are then discharged through a sealed chute into either an oil or water quench.

✦ ✦ ✦

OXIDATION and discoloration of the screws are prevented by means of a protective atmosphere obtained by the partial combustion of coke-oven gas in a combustion-type furnace-atmosphere controller.




# FIRTHALOY BOLT EXTRUSION DIES

Firthaloy Bolt Extrusion Dies offer a real opportunity for Bolt Makers to:

*Reduce Costs in dies and processes*—The remarkable resistance of Firthaloy to wear means longer die life and closer tolerances on maximum production.

*Greater Accuracy in the extruded section*—The smooth extruded surface permits accurate threads which makes possible a true nut fit on every bolt.

*Longer Life in thread rolling dies*—Firthaloy Extrusion Dies make possible perfectly rounded bolts resulting in longer life and lower cost on thread rolling dies.

Firthaloy Bolt Extrusion Dies are successfully used in both heading and trimming—with production measured in millions of bolts.

**FIRTH-STERLING STEEL COMPANY**

Works: McKEESPORT, PA.
NEW YORK CHICAGO HARTFORD
CLEVELAND DETROIT LOS ANGELES
PHILADELPHIA DAYTON
GLOBE WIRE DIVISION, McKEESPORT, PA.

THE low-carbon steel cap screws which are heated at 600 degrees C are water quenched. They are removed from the water quench by an inclined conveyor and are discharged into a tank containing Paralan compound so as to provide a protective coating which will prevent rusting during storage. A second inclined conveyor removes the screws from the Paralan tank and discharges them into tote boxes.

✦ ✦ ✦

ALLOY steel cap screws are manufactured in much the same manner as are the low-carbon steel screws, with the exception that the alloy steel screws are heated in the conveyor-type furnace to their critical temperature and are then quenched in oil. After hardening, the screws are run through the washing machine to remove quenching oil. They are again passed through the conveyor furnace at a lower temperature for drawing. After drawing, the screws are quenched in water and are given a coating of Paralan compound to prevent rusting.

✦ ✦ ✦

THE new washing machine and scale-free hardening furnace, together with the combustion-type furnace atmosphere controller and the auxiliary conveyor system, have reduced the overall cost of heat-treating approximately 50%. The new equipment is easily operated by one man and its operating and maintenance expense is very low, when compared to that of the equipment it replaces. The old equipment, which has been entirely discarded, consisted of an air-atmosphere, conveyor-type, hardening furnace and a conveyor-type, pickling, washing, and drying machine. This equipment required a minimum of two operators and was expensive to operate because of frequent replacement of pickling solution. Maintenance of the equipment was also high due to the corrosive action of the pickling solution. In addition, the pickling vapors, in spite of a large ventilating system, caused considerable corrosion of nearby machines and stored material.

✦ ✦ ✦

ALL of the cold headed standard cap screws are made according to United States Standard gauge, with either fine or coarse threads, as required. The plain steel screws are cold headed and have rolled threads. They are made from cold drawn wire, which is carefully inspected for seams, flakes, and splinters. Since all screws are held to a class three fit, the diameter tolerances are as shown in Table A.

✦ ✦ ✦

THE analysis of the wire must be between the following limits:

**C .08 to .20%**
**Mn .25 to .45%**
**Ph .05 maximum**
**S .05 maximum**

TABLE A

| DIAMETER OF WIRE INCHES | INCHES TOLERANCE |
|---|---|
| .0348 to .08 | .001 plus or minus |
| over .08 to .50 | .002 plus or minus |
| .50 and over | .003 plus or minus |

TABLE B

| WIRE DIAMETER INCHES | TENSILE STRENGTH POUNDS PER SQUARE INCH |
|---|---|
| .0 to .14" | 95,000 |
| over .14 to .182 | 90,000 |
| over .182 to 5/8" | 70,000 |

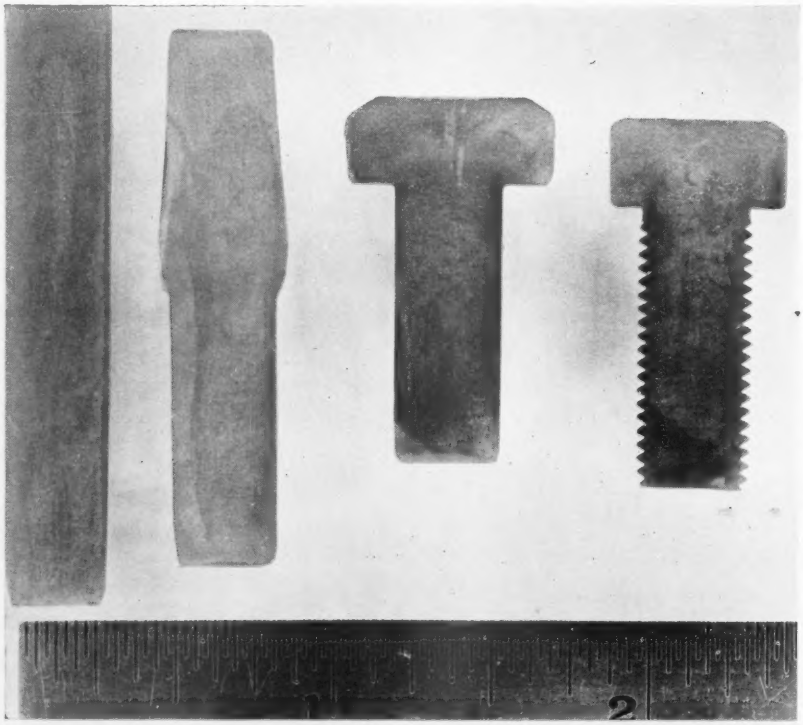


Fig. 7. Steps in the Cold Heading and Thread Rolling of 5/8" cap Screw.

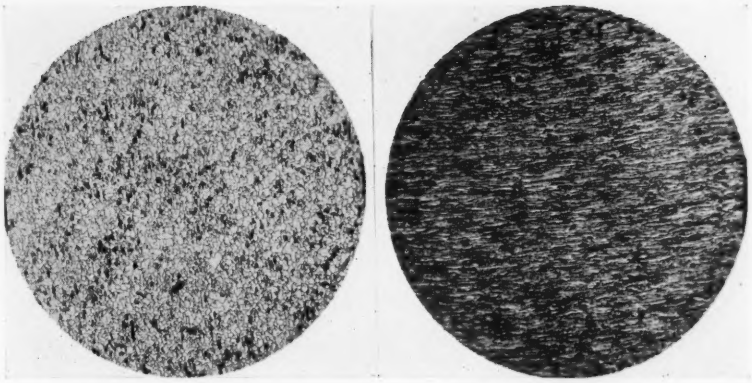
✦ ✦ ✦

THE minimum allowable tensile strength is 50,000 pounds per square inch, with actual tensile strengths preferred as shown in Table B.

✦ ✦ ✦

ALL plain carbon cap screws manufactured from cold drawn wire, as described above, are given a stress relief anneal to recrystallize the metal in the head. The tensile strength of the finished screw is not to be less than 70,000 pounds per square inch.

THE alloy steel screws are usually made from SAE 2315 steel. Their manufacture and physical size specifications are the same as for the low-carbon steel screws. They are, however, hardened and drawn to meet varying strength requirements.



AFTER ANNEAL BEFORE ANNEAL

Fig. 8. Effect of Stress Relief Anneal in Restoring Crystalline Structure in Head of Cold Headed Bolt. Magnification 100X.

✦ ✦ ✦

FIGURES 7 and 8 illustrate the various stages of manufacture of low-carbon steel screws. The microphotographs show the grain structure before and after the strain relief anneal.

✦ ✦ ✦

## Studies for Product Improvement

ALTHOUGH the present plant is operating very satisfactorily and is producing high quality products at satisfactory costs, studies are constantly in progress to determine methods of producing either a better product at the same cost or else the same product at a lower cost.

ONE important method of saving will be the use of heavier coils to feed the cold heading machines. Approximately 15 minutes are required to end up an old coil and start a new one. Larger coils will enable the number of starting intervals to be decreased and in that way will enable a machine to turn out more screws in a given time with no additional attendant labor.

✦ ✦ ✦

THE design and heat-treatment of cold heading dies have been given careful study and, as a result, die life has been increased about 15% over that which was experienced some four or five years ago. Experiments are now in progress to determine the possibility of using a tungsten carbide cold heading die. On the first thought, this may seem to have little chance for success due to the brittleness of the material but preliminary work indicates that success may yet be attained.

✦ ✦ ✦

A FURTHER saving in material cost, as well as increased die life, is expected from the addition of a wire drawing equipment ahead of some of the cold heading machines. Such an equipment will permit the use of hot rolled wire of rather generous tolerances and will permit it to be accurately drawn just before it enters the header. Accuracy in wire size should provide better die life. Also, heading immediately after drawing is expected to eliminate aging effect and thereby provide a wire more easy to cold head.


STEELSKIN

REG. U. S. PAT OFFICE

WIRE DRAWING SOAPS

For High or Low Carbon Wire

TODAY more than ever before we find it necessary to make soap in accordance with the special requirements of a wire mill.

✦ ✦ ✦

SOMETIMES it is a triple sifted soap for stainless steels; sometimes a combination of stearates with soap.

WHATEVER the problem, whether the soap is to be coarse or fine, palm oil or tallow, our production department takes care of all orders to fit the particular needs of our customers.

✦ ✦ ✦

YOUR inquiries invited.

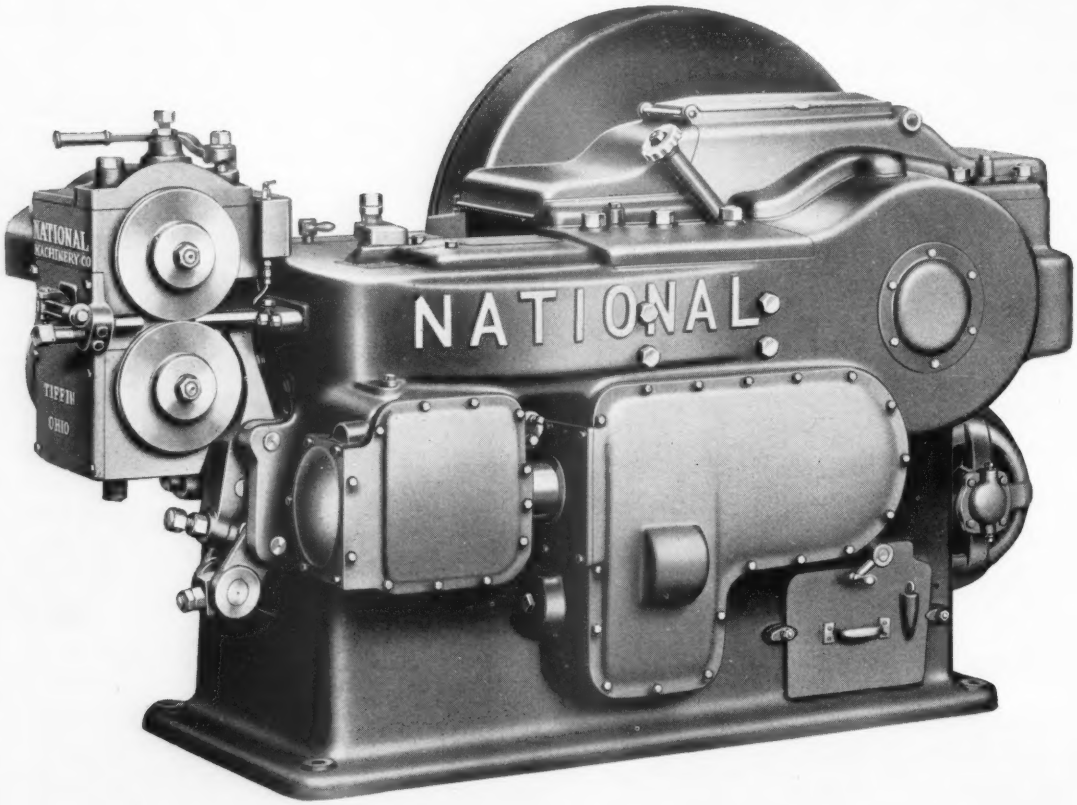
R. H. MILLER CO., Inc. Established 30 years Homer, N. Y.

# Unequalled

## *output - die life - accuracy*

## NATIONAL COLD HEADERS

**are daily proving that their many new and radically improved features really do result in greater output, longer die life and more accurate bolts.**




# NATIONAL

MACHINERY CO., TIFFIN, OHIO

# Cold Drawn Bars

By D. W. McDowell,

Metallurgist, Union Drawn Steel Company, Chicago, Ill.

**A consideration of the physical properties found in cold drawn bars not produced by any other method of manufacture together with an outline of the machinable properties and special uses of such bars for manufacturing purposes.** ✦ ✦

SOMETIME between the years 700 and 1000 A. D. a German monk wrote a description of a wire drawing die. It seems apparent from his article that the art of drawing wire through dies had been practiced for some time. Unfortunately, we have no records of the origin of this product. We do know, however, that the major portion of wire made at this time was used for decorative purposes, and that the Industry has developed from this beginning to the point where it is one of the largest tonnage items found in the many uses of steel and steel products. Its development has been veiled in secrecy and its progress rather slow, but it played no small part in the progress of civilization.

✦ ✦ ✦

COLD Drawn Bars are a comparatively recent development, and this product, which also has a definite place in the scheme of things, can rightfully be claimed an offspring of the Wire Industry. Many of the arts used in Drawing Wire are used in the manufacture of Bars. We are indebted to the Wire Industry for their past researches into pickling fluids, lubricating fluids, and methods of procedure, which procedure was accepted as standard practice when the Cold Drawn Bar Industry was born.

✦ ✦ ✦

ABOUT 1859 a process of Cold Rolling straight bars was patented by a **Bernard Lauth.** It was found that this process of working steel produced a hard tough shaft different from anything on the market at that time. This product, known as Cold Rolled Shafting, became a factor in the Industry, and continued as such until the introduction of a bar drawn through a die in a manner similar to the process used in making Wire. The replacement of the Cold Rolled Bar, plus the demands of the Automotive, Electrical, and Machinery Industries is directly responsible for the rapid growth and development of the Cold Drawn Bar Industry.

✦ ✦ ✦

THE method of procedure in the manufacture of Cold Drawn Bars is very similar in fundamentals to that of Wire. The bars are pickled, lime coated, drawn through dies, cut, and straightened. The equipment used is of special design and can be used for bar stock only. The product is true to section, smooth of surface, bright, free from imperfections, machinable, and has a variety of physical properties not found in Bars produced by any other method of manufacture.

D. W. McDOWELL

Born in Superior, Wisconsin in 1891. Moved to Pittsburgh at an early age and educated in the Public Schools and University of Pittsburgh. Employed by the Pittsburgh Steel Company, Page Steel & Wire Company, Jones & Laughlin Steel Company, and Union Drawn Division of the Republic Steel Corporation where now employed as Field Metallurgist in the Western Territory having Chicago as headquarters.

✦ ✦ ✦

A CONSIDERATION of the latter feature of Cold Drawn Bars is necessary in order to appreciate the greatly diversified uses of the product. We must also bear in mind the fact that nearly all grades of steel can be Cold Drawn, including some of the Stainless types, and that the effect of cold working is similar on all grades.

✦ ✦ ✦

PLATE No. 1 represents the effect on a steel of SAE 1020-X analysis. By reducing the cross sectional area 5% we obtain a 35% increase in the Yield Point and an 18% increase in Ultimate. A reduction of 10% gives an increase of 90% in the Yield Point and a 27% increase in Ultimate. A 15% reduction shows 102% increase in Yield and a 36% increase in Ultimate. Hardnesses show a corresponding increase from 137 Brinell to 187 Brinell.

✦ ✦ ✦

PLATE No. 2 shows the effect produced on an alloy steel of SAE 3135 analysis. A reduction of 10% of the cross sectional area shows an increase of 13% in the Yield and 11% in Ultimate. The hardness shows an increase of 5% from 248 Brinell to 262 Brinell. A correspondingly higher figure is reached with greater reductions.

Analysis: C .16 Mn .72 P .019 S .035

| Condition | Hot Rolled | % Change | 5% Red. | % Change | 10% Red. | % Change | 15% Red. |
|---|---|---|---|---|---|---|---|
| Size | 1-3/32Rd. | | 1-1/16Rd | | 1-1/32Rd | | 1" Rd. |
| Yield Point # per sq.in. | 44,500 | 35% | 61,050 | 90% | 84,500 | 102% | 90,100 |
| Ult.Strgh. # per sq.in. | 69,250 | 18% | 81,750 | 27% | 88,250 | 36% | 94,250 |
| Elong.in 2" | 37% | 47% | 19.5% | 55% | 18.5% | 58% | 15.5% |
| Red.in Area | 65% | 10% | 58.0% | 13% | 56.0% | 15% | 55.0% |
| Brinell | 137 | 24% | 170 | 30% | 179 | 36% | 187 |

Note: Standard .505" diameter test piece used.

Fig.1

SAE 3135 Hot Annealed

| Condition | Hot Rolled | 10% Red. | Percent Change |
|---|---|---|---|
| Size | 1-1/16" Rd. | 1" Rd. | |
| Yield Point # per sq. in. | 102,500 | 116,150 | 13% |
| Ultimate Strgh. # per sq. in. | 131,550 | 146,050 | 11% |
| Elongation in 2" | 15.5% | 9.5% | 32% |
| Red. in Area | 41.0% | 35.0% | 14% |
| Brinell | 248 | 262 | 5% |

Note: Standard .505" diameter test piece used.

Fig.2

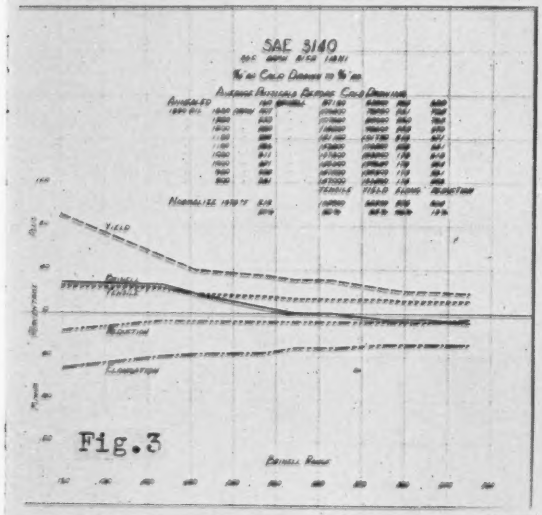



Fig.3

Comparing Cold Drawing and Heat Treating

| Test No. | 1 | 2 |
|---|---|---|
| Size | 1"Rd. | 1"Rd. |
| Yield Point # per sq. in. | 90,100 | 89,150 |
| Ultimate Strgh. # per sq. in. | 94,250 | 107,900 |
| Elongation in 2" | 15.5% | 26% |
| Red. in Area | 55.0% | 67% |
| Brinell | 187 | 228 |

Test No. 1- C .17 Mn .72 Cold Drawn 15% Reduction
Test No. 2- SAE 3135 Quenched Oil 1500 F. Draw. 1200°F.

Fig.4

PLATE No. 3 gives us an idea of what to expect after cold drawing heat treated steels. You will note that the effect on the physical properties decreases as the original hardness is increased. In fact, we have found that when bars having a Brinell of approximately 300 or higher are drawn a decrease in hardness is shown. This shows that cold working is more effective on steels in their soft condition, and also shows that there are very definite limits obtainable by the process.

✦ ✦ ✦

PLATE No. 4 shows the comparative values of a heat treated bar of SAE 3135 analysis and a bar Cold Drawn to the same approximate Elastic Limit. Many cases have come up recently where a Cold Drawn Bar has been used successfully to replace material that had previously been heat treated. This is particularly true of material having an analysis ranging from .30% to .50% carbon in both alloy and carbon bars.

✦ ✦ ✦

A COLD Drawn Bar has the peculiar property of showing an increase in the physicals when annealed at low temperatures. Plate No. 5 shows the effects obtained on a high manganese screw steel annealed at 650°F. The Ultimate increased from 88,450 lbs. to 97,450 lbs., the Elastic Limit from 85,400 lbs. to 89,400 lbs., Elongation from 16.5% to 17.5%, and the Reduction in Area of 52.0% to 55.0% with a corresponding increase in Brinell Hardness from 183 to 192. A rise in temperature to approximately 1000° does not produce any ill effects on the cold drawing properties. Higher tem-

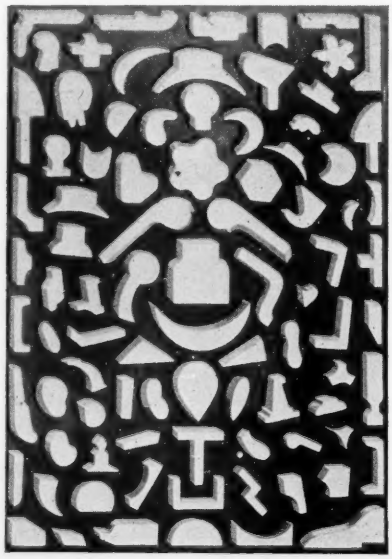


Fig. 6. A few cold drawn shapes being used almost daily. ✦ ✦ ✦

peratures than this show a decline which becomes more rapid as the temperature increases.

✦ ✦ ✦

NEARLY all steels are machinable to some extent in their Hot Rolled condition. The extent of their machinable property will vary depending upon the analysis. By means of Cold Drawing, or Annealing and Cold Drawing we can increase the machinable property. This increase is done by regulating the amount of reduction so that the resultant hardness will fall within machinable limits. Accompanied by a control of the grain structure we produce the Ultimate possibilities known in machinability.

EFFECT OF ANNEALING AFTER COLD DRAWING

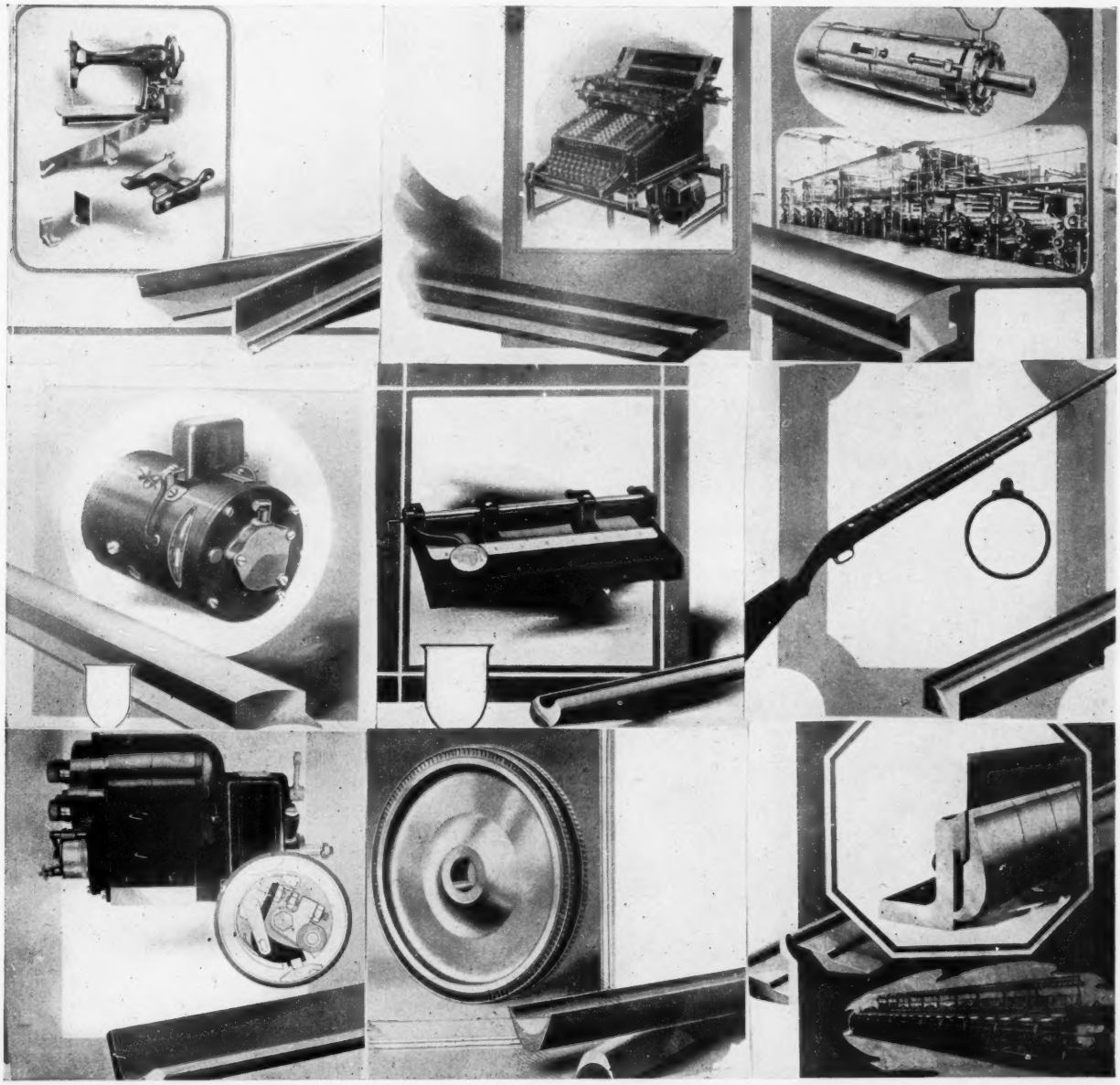
Analysis C .19, M 1.28, P .012, S .116
Size- 15/16 rd. H.R. Cold Drawn to 7/8 rd.

| | Hot Rolled | Cold Drawn | C.D. 650°F | C.D. 975°F | C.D. 1200°F |
|---|---|---|---|---|---|
| Ultimate | 70,400# | 88,450# | 97,450# | 86,450# | 74,650# |
| Yield | 43,900# | 85,400# | 89,400# | 71,600# | 54,450# |
| Elg. 8" | 34% | 16.5% | 17.5% | 22.5% | 29.5% |
| Red. Area | 63% | 52.0% | 55.0% | 57.0% | 65.0% |
| Brinell | 140 | 183 | 192 | 179 | 153 |

Fig. 5

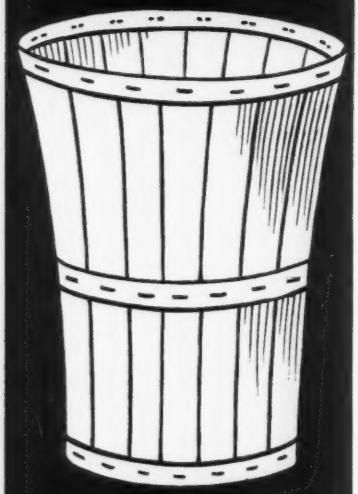
✦ ✦ ✦

SOME mention should be made of the structures which produce



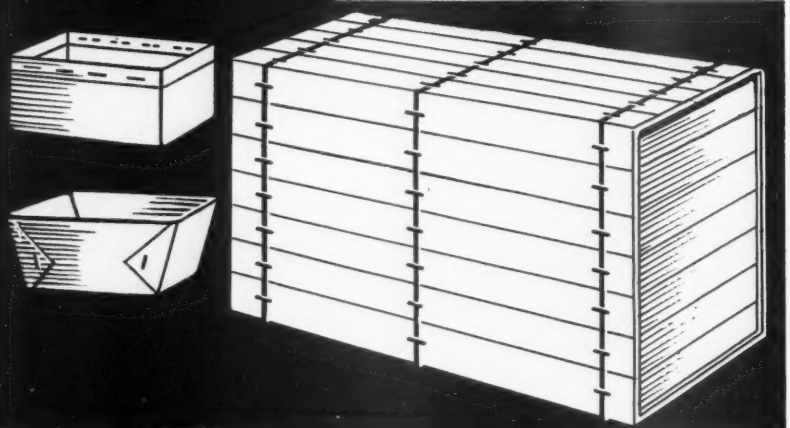
Figs. 7 to 15. Details of some uses of cold drawn shapes shown in Fig. 6. ✦ ✦ ✦ ✦ ✦ ✦ ✦

# Wire
## BINDING STAPLING



For ease of working and security of fastening Continental offers a correct combination of analysis and temper to suit every binding and stapling job. Appearance of the product is enhanced by a choice of widely varied finishes, many of which afford different degrees of rust resistance. Among them are bright, bright and black annealed, galvanized, liquored, coppered, and tinned. Produced by most modern equipment and methods, this quality wire is backed up by prompt, dependable service. Consult our metallurgists on these or any other applications of manufacturers wire.

**CONTINENTAL STEEL CORP.**
General Offices: Kokomo, Indiana
Plants at Canton, Kokomo, Indianapolis



# CONTINENTAL
**STEEL SHEETS AND WIRE PRODUCTS**

Wire: Bright Basic, Annealed, *Konik, Special Manufacturers, Galvanized, *Flame-Sealed

Wire Rods, Nails, Staples, Bale Ties, Barbed Wire; Fence — 15 Types; Gates and Fittings

Sheets: Black, Galvanized, Special Coated; Roofing and Siding — 14 Styles

*Trade Mark Registered, U. S. Patent Office


the most desirable results in machining. Unfortunately, we are unable to definitely point to some particular structure and say it is perfect. The reason for this is that no two shops seem to agree on the subject. Their disagreement is the result of a decided difference in their methods of cutting. In spite of this fact however, we seem to have definitely proven several facts that are worthy of mention. A spheroidized structure in steels of .50% C or less is not desirable. In steels over .50% Carbon it should be graded from zero to full spheroidization in about 1.00% C. A Sorbitic structure is preferable to spheroidization in .50% or less Carbon but not in steels over .50% Carbon. We believe a Lamellar Pearlite is most preferable in all carbons to .50% and a mixture of Lamellar Pearlite and Spheroids in steels over .50% Carbon.

✦ ✦ ✦

ANOTHER feature obtainable in Cold Drawn Bars is the Bar drawn to special shape specifications. These are known as Special Shapes and their applications are limited only by the capacity of the equipment used in their manufacture. Plate No. 6 shows a view of a few of the shapes being used almost daily and Plates No. 7 to No. 15 inclusive show the details of some uses. Considerable saving is effected by the use of Shapes in many products and they have become a Standard part of every Cold Drawn Mill. The average number of new Shapes designed and considered by the trade is approximately 1000 per year.

THERE WILL BE A REGISTRATION FEE OF $5.00 FOR THOSE ATTENDING THE WIRE ASSOCIATION TECHNICAL SESSIONS AND INFORMAL MEETINGS

ADMISSION WILL BE BY BADGE ONLY

✦ ✦ ✦

To Those Registering and Attending the Meetings, stenographic copies of the discussions will be furnished free.

To all others $5.00 per copy.

# "Double Treating" Track And Frog Bolts

By Charles Fassinger, Vice President
Oliver Iron and Steel Corporation, Pittsburgh, Pa.

**A comparison of the physical properties of Double Treated Bolts with those manufactured by regular commercial practices involving a single treating operation,—Time Quenching.** ✦

## Foreword

THROUGH the years there has been little change in the methods used in the manufacture of heat treated track and frog bolts. The usual practice consists of the following operations:

**(1) Heating for forging.**
**(2) Hot heading**
**(3) Rolling thread while hot.**
**(4) Time quenching from forging heat (usually in oil).**
**(5) Drawing with residual heat.**

✦ ✦ ✦

AN analysis of this practice shows that up to the quenching point satisfactory conditions prevail, that is temperature losses from heading and rolling operations are not great enough to preclude the consistent securing of a full quench. If the material is subjected to a full quench a satisfactorily hardened state is produced.

✦ ✦ ✦

UNDER the usual practices, however, the material is not subjected to a full quench. As indicated above, it is subjected to a partial or time quench. The practice of time quenching involves an exactly controlled period of time in the quenching bath so as to withdraw only the correct amount of heat, the residual heat being used for a draw in order to secure the desired measure of ductility. Unfortunately, the usual practices previously mentioned, do not permit the exact control of temperature at the time of entry in the bath, and, since quenching time is constant regardless of irregularities in initial temperature, variations occur in the residual heat contained in the bolts leaving the quenching medium. In addition another factor affects the effectiveness of the time quench. A differential exists between the threaded end of bolt and the shank. The quench is more effective in the threaded end because of the greater amount of exposed area. This results in lack of uniformity both as to hardness and ductility.

✦ ✦ ✦

## Physical Properties Improved by Reheating After Quenching

TO overcome these objectionable features we have refined our manufacturing procedure to provide a full quench and a draw by reheating to a predetermined temperature. We have found that a proper drawing temperature following a full quench compensates for the hardness variation due to sectional differences in the bolt. Subsequent experience has indicated that it is possible to employ the most suitable quenching material which is determined by the chemistry and section of the bolt. Tests show as a direct result of the "double treatment" procedure that at a specified tensile strength the ductility of the "double treated" bolt is much higher than that of the time quenched bolts. The reduction of area is approximately fifty per cent greater and elongation is about double. Another favorable consequence is that "double treated" bolts when measured by Brinell tests are satisfactorily uniform in hardness throughout the entire length of the bolt, while, as mentioned before, time quenched bolts vary greatly between the shank and the threaded section.

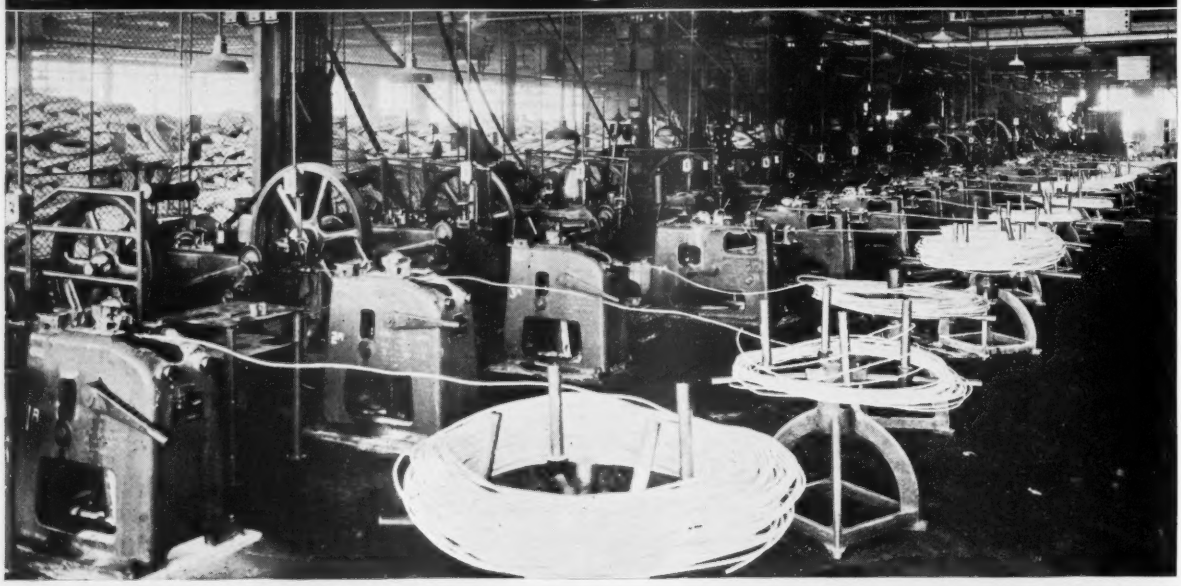
CHARLES FASSINGER

**Connected with the Oliver Iron and Steel Corporation for forty-five years. Began to work for the company in 1892 at the age of twelve, as a laborer. Went to night school for ten years, taking on more and more responsible jobs in the mill. In 1922 made General Superintendent. In 1937 vice-president in charge of production. Member The Wire Association.**

✦ ✦ ✦

THE equipment required to "double treat" bolts permits us to approximate a fully hardened product for any period of time in the quenching bath above fifteen seconds. Micrographs of treated bolts show a full quench and uniform structural conditions prior to the draw. This is a most desirable condition. Laboratory impact tests (see illustration) have indicated that the values of "double treated" bolts are consistently fifty per cent higher than time quenched material. This will indicate the importance of exact heat treating; the exact quenching control to secure bolts possessing maximum physical values and uniform internal structure.

# 100% Equipped



## with AJAX-HOGUE WIRE DRAWERS

- LONGER DIE LIFE
- LOWER MATERIAL COSTS
- IMPROVED PRODUCTS
- CLOSER WIRE TOLERANCES
- REDUCED INVENTORY

Since the introduction of the Ajax-Hogue Wire Drawer only two years ago, seven manufacturers of cold headed products have equipped their plants 100% with these new machines. Shown above is the installation of Acme Machine Products Division of the Serrick Corporation in Muncie, Indiana, where a total of 18 Ajax-Hogue Wire Drawers equips their cold header department 100%.

In all seven of these plants, the complete installation followed the purchase of a single unit, which proved beyond a doubt the profitable performance of this unique machine.

The Ajax-Hogue Wire Drawer cold draws and coats hot-rolled, pickled and limed stock as it feeds into the header, saving the differential in cost between the hot-rolled and the more expensive cold-drawn stock ordinarily used.

In addition, it greatly improves the quality and accuracy of the product and substantially increases die life due to easier heading immediately after drawing.

If you are a manufacturer of cold headed products, it will pay you to investigate the profit possibilities of this machine at once. We suggest that you write today for Bulletin No. 111 for complete details.

**THE AJAX MANUFACTURING COMPANY**

EUCLID BRANCH P. O., CLEVELAND

621 MARQUETTE BUILDING
CHICAGO, ILL.

201 DEWART BUILDING
NEW LONDON, CONN.

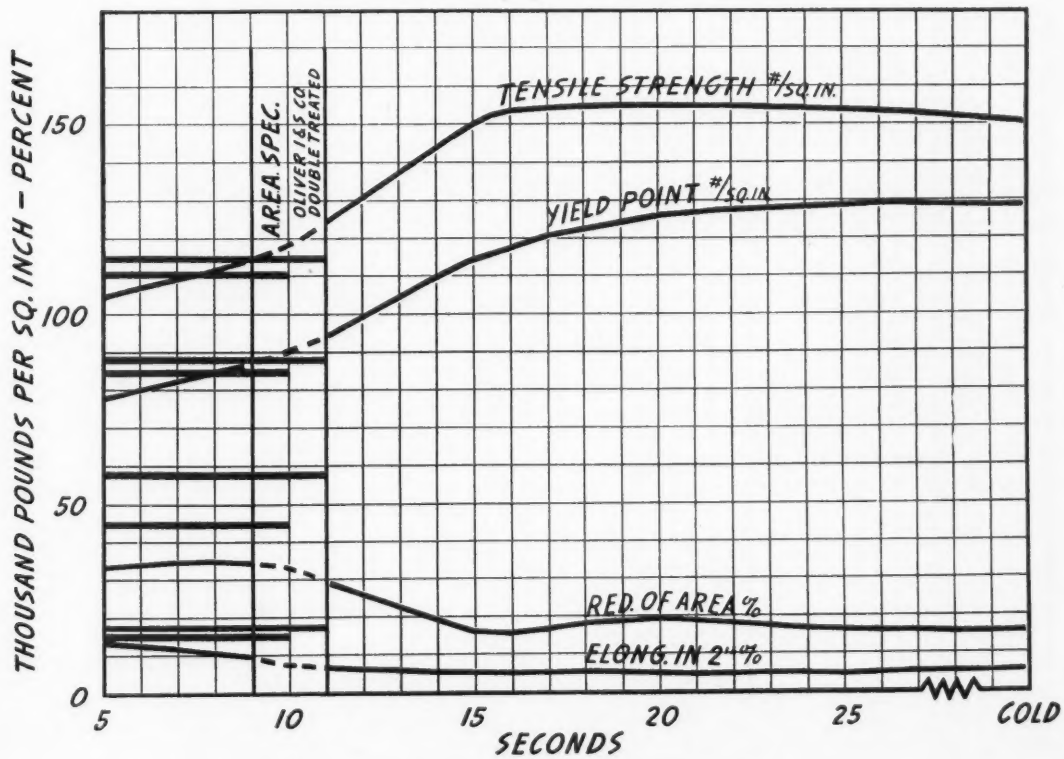
**TABLE 1**
**SUMMARY OF TEST ON ⅞" x 4½" TRACK BOLTS**
**Heat Treated and Tested in Full Section**

| | Standard .505" Test | | | | Brinell Number | | | Strip Test | |
|---|---|---|---|---|---|---|---|---|---|
| | Yield Point | Tensile Strength | Elong. 2" % | Red. Area % | Surface: Thread | Surface: Shank | Center | Lbs./Sq. In. .731 Dia. | Broke In |
| O. I. & S. Double Treated Track Bolt | 90850 | 117700 | 18.0 | 57.0 | 277 | 269 | 248 | 105000 | Thread |
| | 88300 | 115650 | 20.0 | 57.5 | | | | 102500 | Thread |
| **TIME QUENCHED IN OIL** | | | | | | | | | |
| 5 Sec. | 80150 | 103050 | 12.5 | 31.5 | 440 | 187 | 207 | 93110 | Thread |
| 5 Sec. | 78000 | 101600 | 18.0 | 39.1 | 420 | 207 | | 97800 | Thread |
| 10 Sec. | 98250 | 119600 | 10.0 | 38.6 | 415 | 228 | 229 | 115780 | Body |
| 10 Sec. | 88950 | 117600 | 9.0 | 33.0 | 400 | 212 | | 113200 | Body |
| 15 Sec. | 123000 | 151950 | 8.0 | 18.5 | 370 | 286 | 302 | 134980 | Body |
| 15 Sec. | 107000 | 149750 | 10.0 | 20.8 | 360 | 269 | | 139690 | Body |
| 20 Sec. | 124800 | 156850 | 7.0 | 21.9 | 350 | 321 | 285 | 153430 | Body |
| 20 Sec. | 136150 | 155950 | 7.0 | 22.4 | 340 | 302 | | 154080 | Body |
| 25 Sec. | 125400 | 155900 | 8.0 | 23.7 | 387 | 330 | 302 | 165200 | Body |
| 25 Sec. | 134850 | 153900 | 6.0 | 15.1 | 340 | 310 | | 152100 | Thread |
| Cold | 123450 | 151000 | 8.0 | 15.8 | 477 | 300 | | 144580 | Thread |
| Cold | 135500 | 148800 | 7.0 | 18.0 | 418 | 280 | | 146780 | Thread |

Ladle Analysis ..... Car .47 Mang. .77 Phos. .019 Sul. .033

**CHART OF PHYSICAL PROPERTIES**

**Of Time Quenched 4½" x ⅞" Bolts with Minimum Properties of Specification and Actual Properties of "Double Treated" Product Superimposed.**



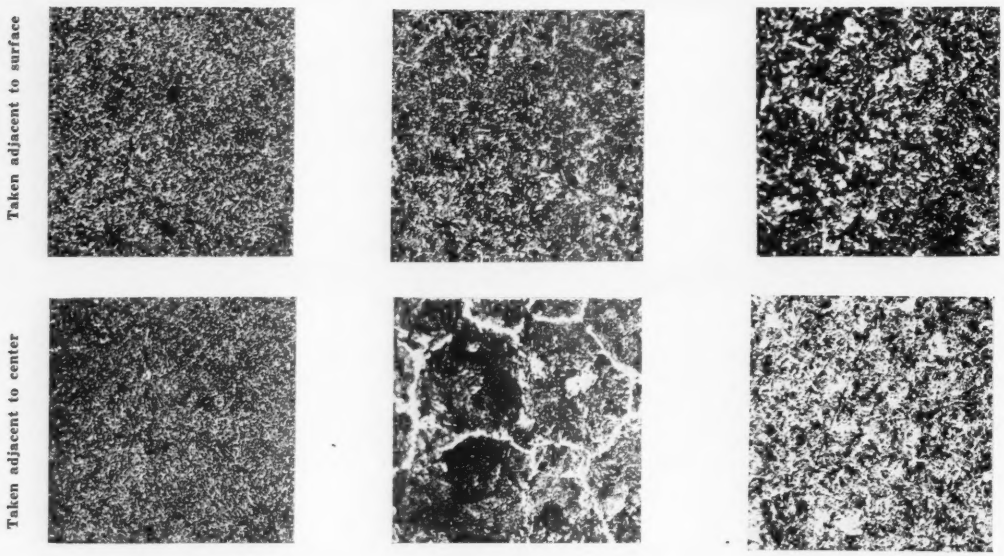

**REQUIRED A.R.E.A. PHYSICAL PROPERTIES**

| | | | |
|---|---|---|---|
| Yield Point ..... | 85,000 lbs./Sq. In. | Elong. in 8" ..... | 16% |
| | | Elong. in 2" ..... | 15% |
| Tensile Strength ..... | 110,000 lb./Sq. In. | Red. in Area ..... | 45% |
| | | Bend Test ..... | 90% |

## MICROGRAPHS

### 100 DIAMETERS

Time Quenched in Oil




Double Treated
Water Quenched and Drawn

Quenched 5 Seconds

Quenched 10 Seconds

## BENDING TESTS

### TREATMENT SAME AS ABOVE

Double Treated

Quenched 5 Seconds

Quenched 10 Seconds

MICROGRAPHS—The structure of the bolts after "Double Treatment" is uniformly that of the pictures shown. The full quench followed by drawing to a correct definite temperature insures consistent reproduction of this condition. The regularity with which the structure is secured with "Double Treatment" and the irregularities and consequent non-uniformity occurring with Time Quenching are both reflected in the physical properties as tested.

✦ ✦ ✦ ✦ ✦ ✦ ✦

THE accompanying tables, charts, micrographs, and photographs are illustrative of the properities now being secured and substantiate the statements which have been made above.

✦ ✦ ✦

IN Table I for the size of bolt stated, 7/8" x 4½", the physical properties as tabulated and charted show—

**That for the specified tensile strength the ductility of the "Double Treated" bolts is much higher than for the Time Quenched. The reduction of area is approximately 50% greater and the elongation is approximately double.**

**That with a single Time Quenching treatment the difference in tensile strength per second of time in the quenching medium is approximately 4000 lbs./Sq. In., (up to time cycles of 15 seconds), hence exactness of the quenching cycle is essential.**

**That the "Double Treated" bolts are satisfactorily uniform in hardness throughout as measured by Brinell tests while the Time Quenched bolts vary widely between the thread and shank sections at the surface and also between the surface and center in the threaded section.**

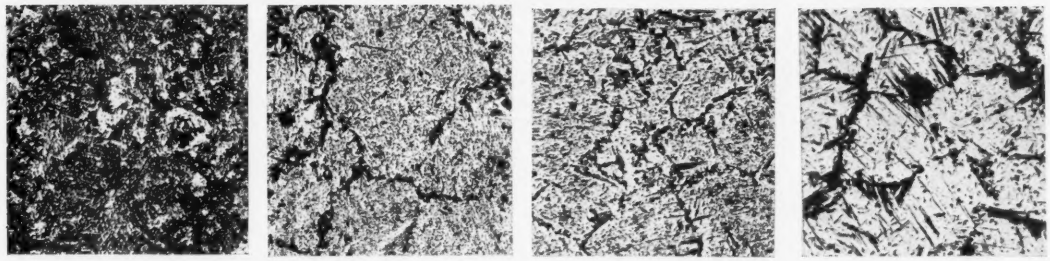
**That a fully hardened product is approximated for any period of time in the quenching bath above 15 seconds, as graphically shown on the chart, and consequently results in a minimum of ductility.**

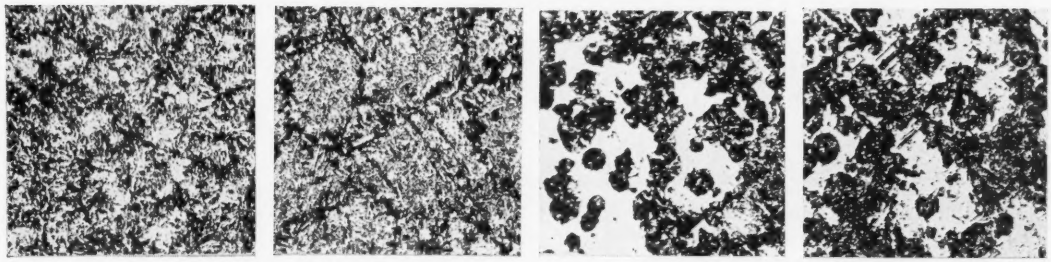
✦ ✦ ✦

## MICROGRAPHS

**100 DIAMETERS**

**Time Quenched in Oil**

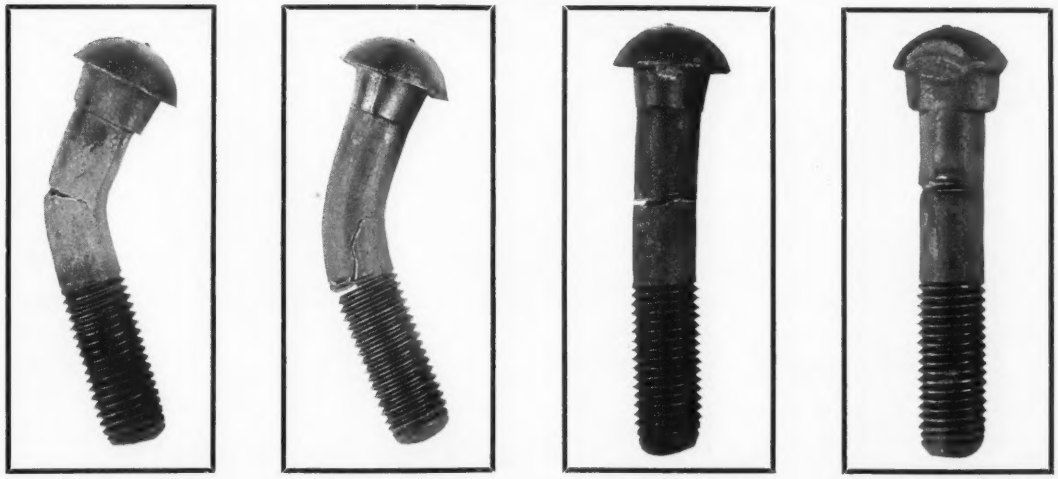




**Quenched 15 Seconds** | **Quenched 20 Seconds** | **Quenched 25 Seconds** | **Quenched Cold**

## BENDING TESTS

**TREATMENT SAME AS ABOVE**



**Quenched 15 Seconds** | **Quenched 20 Seconds** | **Quenched 25 Seconds** | **Quenched Cold**

**BEND TESTS—The contrast between the bends made of bolts given a "Double Treatment" and those Time Quenched only illustrates the effect of varying degrees of hardness and lesser degrees of ductility.**

✦ ✦ ✦ ✦

THE uniformity of "Double Treatment" is emphasized by the data shown in Table 2.

**Three different bolts processed in the same manner except that delays in time in addition to those commonly incurred in the operations were provided for as shown and —**

**The physical properties are satisfactorily uniform.**

**The microstructures indicate a full quench prior to the draw and uniform desirable structural conditions.**

**The pictures of the tensile tests show how the tests are reduced in area in the threaded section adjacent to the rupture due to uniformly high ductility and the desirable structural conditions.**

✦ ✦ ✦

## Advantages

THE treatment definitely includes a full quench in water or oil and an accurately controlled draw. The "Double Treatment" produces controlled uniformity of suitable structural characteristics and superior physical properties which insure—

**1—Greater uniformity of tensile and yield strength.**

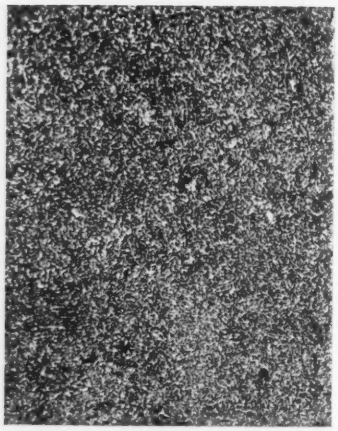
**2—Greater ductility for a given tensile strength as measured by elongation and reduction of area.**

**TABLE 2**
**SHOWING UNIFORMITY OF PHYSICAL PROPERTIES OBTAINED BY DOUBLE TREATMENT, WHEN INTRODUCING A TIME VARIABLE BETWEEN FORGING AND QUENCHING**

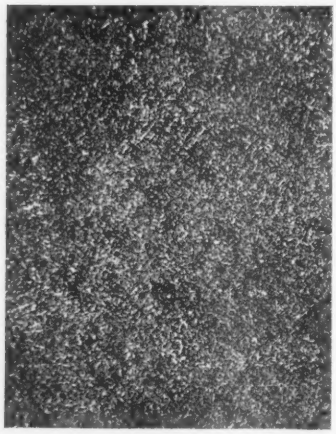
| Time Held After Forging Before Quenching | Standard .505" Dia. Tensile Test | | | | Strip Test | |
|---|---|---|---|---|---|---|
| | Yield Point | Tensile Strength | Elong. in 2" % | Red. of Area % | Breaking Load | Test Broke In |
| 10 Sec. | 100100 | 117900 | 20.0 | 57.5 | 122500 | Thread |
| | 99400 | 115300 | 22.0 | 58.8 | 123300 | Thread |
| 30 Sec. | 100350 | 115600 | 22.0 | 58.6 | 122800 | Thread |
| | 101900 | 116800 | 18.0 | 56.0 | 123950 | Thread |
| 60 Sec. | 102300 | 116250 | 20.0 | 59.6 | 119200 | Thread |
| | 104550 | 116050 | 19.0 | 60.4 | 121000 | Thread |

MICROGRAPHS OF STRUCTURE AND PHOTOGRAPHS OF TEST SPECIMENS SHOWING UNIFORMITY OF TEST

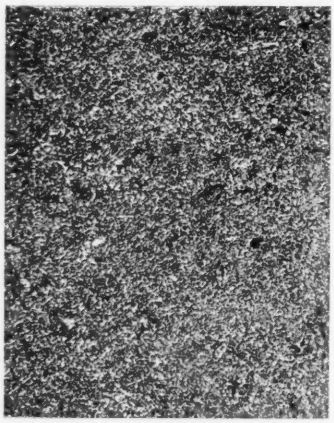
100 DIAMETERS



10 Seconds



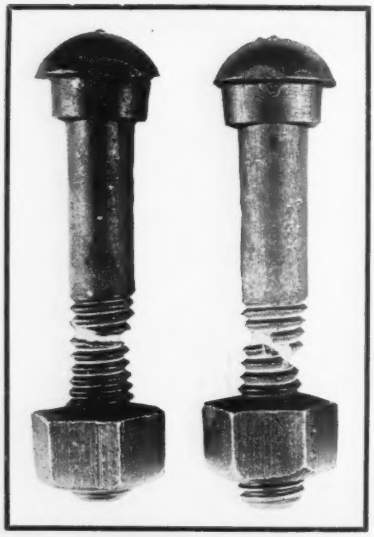
30 Seconds



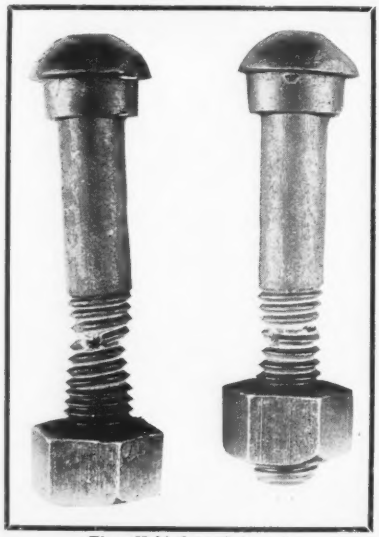
60 Seconds

TENSILE TESTS

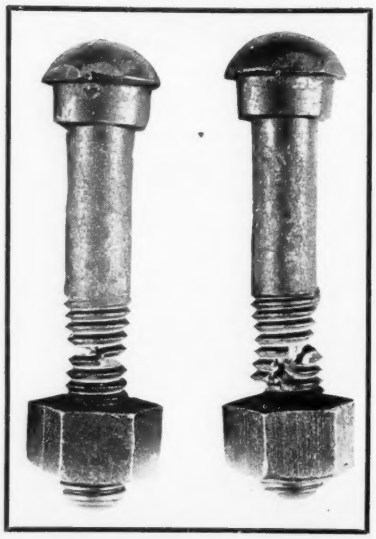
½ ACTUAL SIZE



10 Seconds



Time Held Out of Quench
30 Seconds



60 Seconds

★The sole specification on many requisitions, "Same as last order," demonstrates customer recognition of the exceptional uniformity of Rustless stainless steel. Maintaining such standards demands the utmost in skill and care.

★Rustless concentrates exclusively on the one job of making finer stainless steel. Rustless bars and wire can prove themselves by performance in *your* shop, as they have in others.

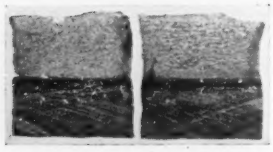
RUSTLESS IRON AND STEEL CORPORATION · BALTIMORE, MARYLAND

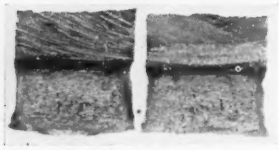
Visit Our Booth—A-22—at The National Metals Exposition

**RUSTLESS**
CORROSION AND HEAT-RESISTING
STAINLESS STEELS

## CHARPY IMPACT AND BEND TESTS
### MADE AT SUB-ZERO TEMPERATURE (-25°F)

Oliver I. & S.
Double Treatment

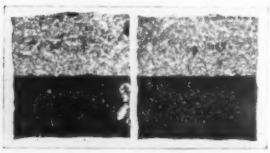


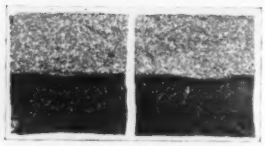


2 Diameters

½ Actual Size

Time Quenched





These tests, at a low temperature, were made to check the physical properties under adverse conditions that might be encountered, to some extent, in actual service. The high quality of the "Double Treated" bolts is emphasized by the superior impact and bending properties at sub-zero temperatures.

✦ ✦ ✦ ✦ ✦ ✦

3—Higher resistance to impact at both atmospheric and sub-zero temperatures.

4—Consistently satisfactory bends at atmospheric temperature and

5—Superior bending properties at temperatures below zero.

✦ ✦ ✦

**SUMMARY OF CHARPY IMPACT AND BEND TEST**
**Made at Sub-Zero Temperature (-25°F.)**

| Treatment | Charpy Impact Ft.-Lbs. | Bend Test ° |
|---|---|---|
| Oliver I. & S. Double Treatment | 28—23 | 90°—90° |
| Time Quenched | 9—17 | 52°—68° |

To Those Registering and Attending the Wire Association Meetings

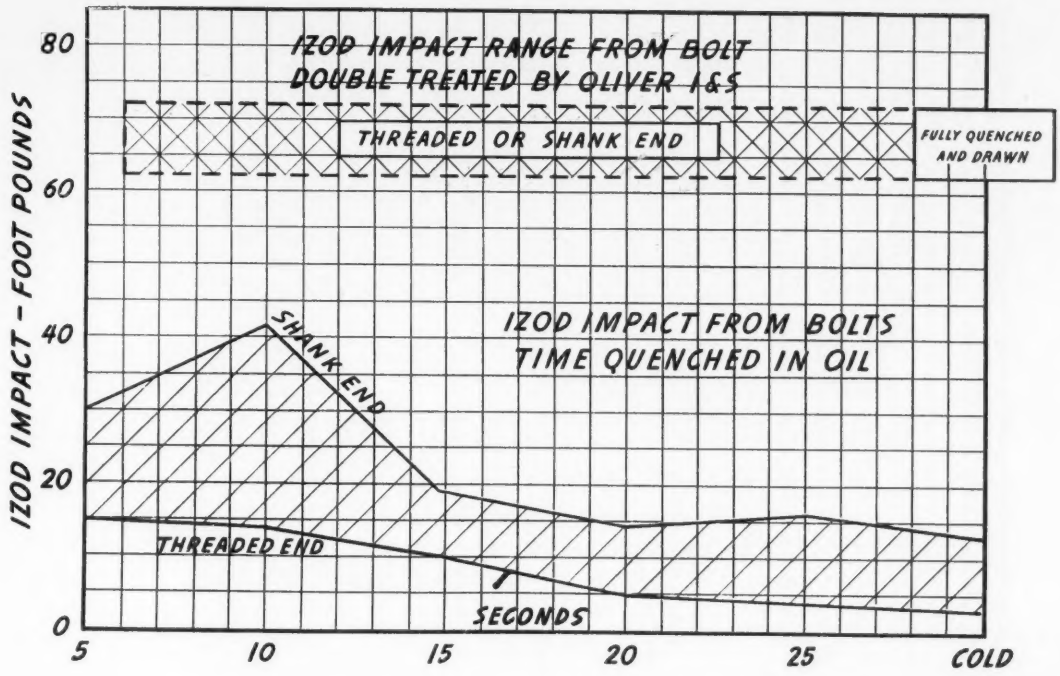
THERE WILL BE A REGISTRATION FEE OF $5.00

Admission will be by Badge Only

To Those Registering and Attending the Meetings,

Stenographic Copies of the Discussions will be Furnished Free

To All Others, $5.00 per Copy




**IZOD IMPACT VALUES—DIFFERENT TIME QUENCHES**

**(Tests Made at 70° F.)**

**FOOT—POUNDS**

| Section | 5 Sec. | 10 Sec. | 15 Sec. | 20 Sec. | 25 Sec. | Cold |
|---|---|---|---|---|---|---|
| Threaded | 15—19 | 24—27 | 10—12 | 5—6 | 4—7 | 3—6 |
| Shank | 29—30 | 28—42 | 12—13 | 13—15 | 13—17 | 7—13 |

The impact results substantiate the point previously made with tensile tests. Exact control in heat treatment is necessary to secure the maximum values and a wide variation in resistance to impact occurs between the shank and threaded section with Time Quenching. The quality of the "Double Treated" product is well illustrated by the impact values which are uniformly 50% higher than the highest secured on Time Quenched material with the most efficient quenching cycle and most advantageous location of test.

**DOUBLE TREATMENT**
**Foot—Pounds**

| | |
|---|---|
| Threaded | 69—71 |
| Shank | 64—71 |


KELLY WIRE DIE CORPORATION

D-i-a-m-o-n-d D-i-e-s ▲▲▲ C-a-r-b-i-d-e D-i-e-s

No Matter What Your Requirements May Be

THE PERFECT DIES FOR PERFECT WIRE

are

KELLY DIES

▼▼▼

**KELLY WIRE DIE CORPORATION**

19 WEST 34TH STREET — OPPOSITE EMPIRE STATE BUILDING — NEW YORK, N. Y.

# ANNOUNCING ❖ ❖

## The Organization of a New Division of the Wire Association Devoted to

# NON-FERROUS METALS

E. W. CLARK, Mechanical Engineer,
Wire and Cable Section,
General Electric Co., Schnectady, N. Y.
Chairman of Division

THE 1937 MEETING
WILL BE HELD AT ATLANTIC CITY, N. J.
OCTOBER 18th TO 22nd INCLUSIVE
IN ASSOCIATION WITH
THE NATIONAL METAL CONGRESS

### PURPOSES:

The specific purposes are to promote the art of working non-ferrous metals together with the application of metallurgical and scientific studies to these and related problems and to improve the manufacturing processes of non-ferrous rod, wire, strip and tubing, electric wire and cable and insulated wire and cable.

✦ ✦ ✦

### FUNCTIONS:

THE division functions along the following lines:

1. The use of the Association headquarters as a central clearing house for information and data of all kinds which may be of interest to members.
2. The exchange of ideas on processes of production including machinery, technical processes, etc.
3. The establishment and maintenance of friendly relations among the members of the association and the development of sectional and national meetings to discuss matters of mutual interest.
4. Studies of production methods and analysis of production costs.
5. Developments in the use of new materials and new applications of existing materials and by-products.
6. Research and collection of information on personnel management, including such factors as labor turnover, seasonal changes in the demand for employees, wage scales, etc.
7. Standardization and simplification as a means for the effective elimination of waste.
8. Such other subjects as may be determined upon.

✦ ✦ ✦

### ACTIVITIES:

DURING the year the following activities will be in operation:

1. Each month there will be published in WIRE AND WIRE PRODUCTS, the designated "Official Publication" of The Wire Association, at least one article or research paper relating to the subjects covered in the outline of "PURPOSES". These papers will be contributed by writers fully conversant with the subjects presented.
2. The Wire Association information service—A cooperative confidential service through which members exchange ideas and endeavor to aid each other in process and production problems. No identities are revealed without specific authorization. Questions and answers are given a number and all data transmitted under the allocated number.
3. The annual Wire Association technical meetings held annually in association with the National Metal Congress. At this convention each division of The Wire Association holds three sessions on non-conflicting dates as follows: 1. Metallurgy and Research. 2. Processes and Machinery of Production. 3. Insulated wire and cable.

NON - FERROUS
METALS AND ALLOYS

Vol. 12 OCTOBER, 1937 No. 10

# The Need of a Better Quality of Copper In Apparatus Manufacture

By L. H. Burnham,
Development and Power Transformer Engineer,
General Electric Co., Pittsfield, Mass.

Many electrical apparatus failures may be caused by defects in copper wire. The consequent necessity for the elimination of dangerous rod and wire imperfections is stressed and some suggestions for improvement made herewith. ✦ ✦ ✦ ✦

## Progress

TODAY, in millions of homes, the electric switch brings the radio, light, heat, and power for many electrical appliances. Electricity is being used more and more in our daily lives, and it is rapidly becoming the untiring and faithful servant of mankind. Without electricity, modern industries could not exist for one hour.

✦ ✦ ✦

PROGRESS is best measured by comparison. Think of the candle light versus the incandescent lamp of today; the ox-cart versus the automobile; the open fireplace versus the white, clean, and efficient electric range; the old springhouse in the orchard versus the electric refrigerator now in the kitchen; and many other labor-saving appliances. All of these appliances must be the last word in compactness, safety, dependability, and economy.

✦ ✦ ✦

THE General Electric Company manufactures hundreds of these different electrical devices, also miniature lamps, large transformers, and large turbo-generators. Just one of these very large machines may require a whole train-load of freight cars for shipment to destination.

L. H. BURNHAM

Born London, Ohio and graduated from Ohio State University at Columbus, Ohio with degree M. E. in E. E. First worked for Stanley Electric and Manufacturing Co. at Pittsfield, Mass. and now employed in the Transformer Engineering Dept. of General Electric Co. at Pittsfield, Mass. Engineer of the development, design and manufacture of air insulated, oil filled and Pyranol railway and power transformers. Also general supervision of the copper wire, cleaning, scouring and insulating for use in these transformers. Recipient of General Electric Co. Coffin Award for meritorious achievement in Engineering. Associate Member of American Institute of Electrical Engineers. Past Chairman of Pittsfield Section of A. I. E. E.

IN this list of manufactured products must be included motors, regulators, current transformers, washers, ironers, flat-irons, etc. All of these articles are built to satisfy the rapidly increasing demand of the consuming public, which grows more eager each year, to raise their standard of living by purchasing new and better appliances. All products must be of highest quality, to stand up successfully under the rough treatment given by the many different individuals of different dispositions.

✦ ✦ ✦

HOWEVER, not one of these devices is perfect. We must continually study ways and means to make these devices better and better. If we do not, someone else will.

✦ ✦ ✦

## Copper Demand

ALL of these products require copper. The continual demand is for copper, more copper, and still more copper. The General Electric Company alone uses many million pounds of copper yearly. A great percentage of this copper is used in wire form, varying from .0025" in diameter (the diameter of a human hair) to large size bus bars.

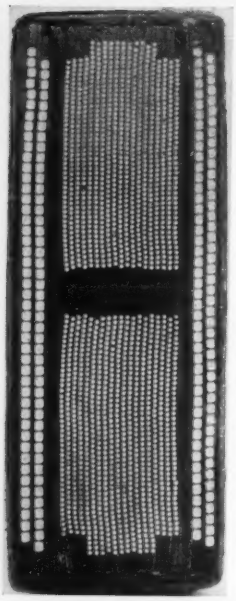


Fig. 1. Transformer-Coil Section.

Fig. 2. Sample of Rectangular Conductor Insulated with Combined Paper Cotton Covering.

EVERY day the General Electric Company uses from five thousand to six thousand miles of copper, or almost two million miles in one year. If one year's supply of wire were strung in a continuous length, it would be equivalent to four trips from the earth to the moon and back, or could be wrapped eighty times around the world at the equator.

## Application

THIS wire is wound into coils of many sizes and various shapes, which always operate in service with a steady or intermittent voltage stress between turns. (See Figure 1.) Because of this stress, each strand of wire must be carefully insulated and separated from the adjacent strand by the minimum distance permissible for safe operation.

INSULATION of these copper strands consists of enamel, cotton, paper, silk, synthetic resin, asbestos, etc. These insulating materials are placed around the copper in very thin or multiple layers, varying in thickness from a few thousandths of an inch upwards to ¼″ wall, or more. (See Figure 2.)

## Potential Danger of Wire Imperfections

WHEN such minute distances between adjacent turns are involved, the bare copper strip must not contain defects, such as projecting points, fins, slivers, copper dust, rough or crooked sections which would, in any way, reduce the dielectric strength by injuring the insulating material around the strand. (See Figures 3 and 4.)

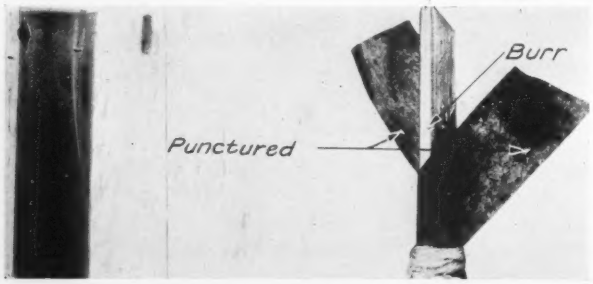



Fig. 3. Piece of Copper Wire, 0.700 by 0.100 in. View Showing a Sliver.
Fig. 4. Paper Covered Wire Showing Effect on the Insulation of a Copper Burr.

GENERALLY, lightning strikes projecting points. The miniature lightning existing between turns of a wound coil follows the same law, and will choose to start from the burrs or slivers, which may be on the conductor. One small projecting burr on a single copper strand might easily be the cause of a short circuit between turns, quickly putting out of service any size of device, from a small relay to a 100,000 Kva transformer, or a 200,000 Kva turbo-generator.

A SHORT circuit of this kind may release a tremendous amount of power, which ruins not only the windings of the particular device, but may also, due to the excessive current flow, develop short circuit forces totaling many thousands of pounds, which can seriously damage the clamping structure of the device as well as other apparatus in the station. Further, the power supply is interrupted, which means loss of revenue to the operating company, inconvenience and disgust of the consumer.

IN some cases, many weeks are required to repair a burned-out transformer or turbo-generator. Besides the delay and inconvenience, the repairs may cost many thousands of dollars. Just realize that one small burr or sliver on the copper conductor may easily be the cause of a serious failure of this kind.

## Wire Manufacture

THE General Electric Company receives copper, generally in rod form, which is coiled. The finish is dull, copper, and it is known as "hot rolled rod". From this form it is cold-drawn by a series of operations into round wire of various diameters, which has a smooth finish, and is known as "bull ring wire". (See Figure 5.)

✦ ✦ ✦

THIS "bull ring wire" is then drawn or rolled into round or rectangular shape for use in various kinds of windings. Edging rolls are used to maintain the correct radius on the corners of rectangular wire.

✦ ✦ ✦

EACH cold working operation, drawing or rolling, hardens and stiffens the copper, making frequent annealing a necessity to facilitate handling and shaping. When the wire has been reduced to the correct size, it is given a final anneal just previous to scouring, inspection and insulating.

✦ ✦ ✦

## Imperfections in Bare Wire

COPPER wire, whether round, square, or rectangular, after being drawn or rolled to the required dimension and annealed, may contain burrs, slivers and copper dust, which adhere to the edges and surfaces of the wire. (See Figures 7, 8, 9, 10, 11, 12.)

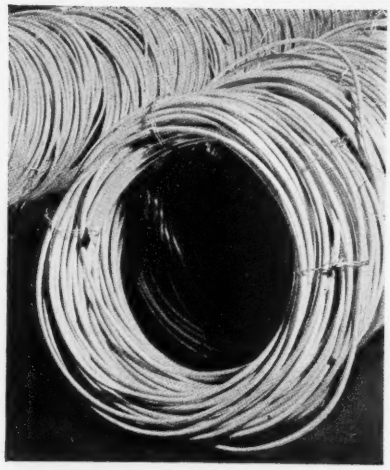


Fig. 5. Hot-Rolled Rod Made From Copper Ingot

✦ ✦ ✦

THE greater the number of reductions and annealing operations, the fewer slivers and burrs will be found on the finished wire. These slivers may originate from defects in the wire due to slag or oxide in wire bar, incorrect hot rolling operations, fins accidentally made in hot rolling, damage during cold rolling, and handling during transportation.

## Removal of Imperfections

THESE defects are carried on throughout all succeeding reducing processes, and extreme care must be exercised to remove all imperfections before applying the insulation. Much money has been spent in developing, scouring, and cleaning devices designed to remove these imperfections without reducing the cross section or damaging the wire in any way. The presence of these defects in wire, round or rectangular, has been an admitted fact for years, but highly efficient scouring and cleaning devices are used by the company to eliminate them. (See Figure 13.) However, practically every one of our plants is continually at work developing better methods to improve the drawing, rolling, annealing, scouring and cleaning operations. The copper suppliers also should be active in this development, and make very strenuous efforts to eliminate imperfections in the wire bar and rod.

✦ ✦ ✦

## Copper Dust

NOT only must burrs and slivers be carefully removed from the bare copper, but also the copper dust. This applies especially to wires which are enameled. The copper dust adhering to the wire

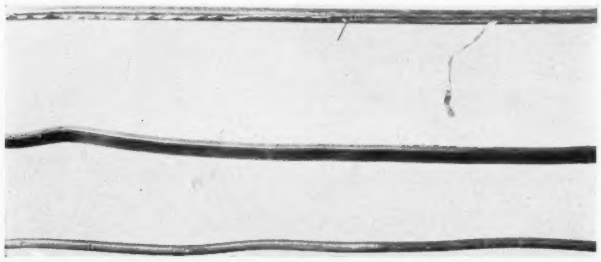


Fig. 7. Defects in Bare Copper, Round and Rectangular Wire Caught During Inspection Shows Burrs and Slivers. ✦ ✦ ✦

Fig. 8. Burr on Copper Wire. ✦ ✦ ✦ ✦

CHART 1

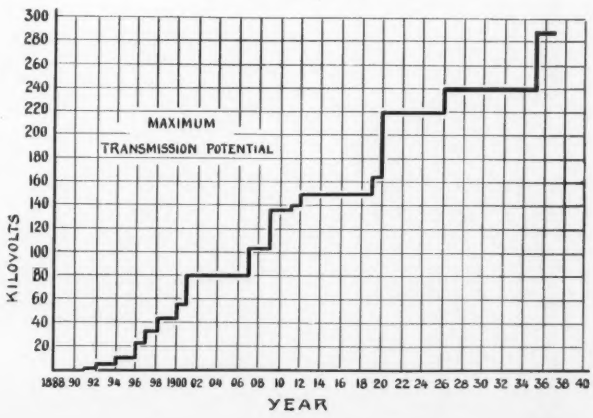
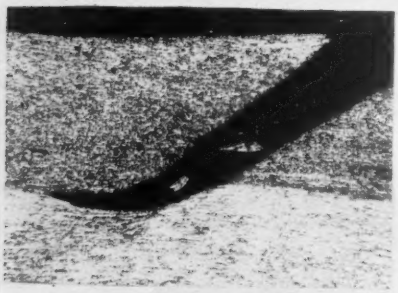


Figure 9. Slivers in Copper Wire. * * *

Larger Diameter Sample

×5

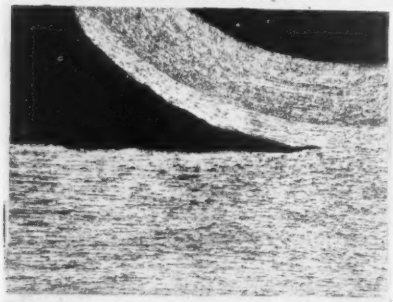


×50.

P D #3
Longitudinal view
of one of
above checks

Smaller Diameter Sample

×6

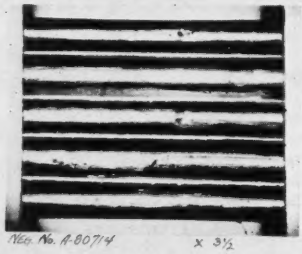


×50

Longitudinal view
of one of
above checks

Figure 10. Bull Ring. * * * * *

.114 BULL RING COPPER WIRE
DRAWN FROM 3/8" ROD. — .209
BREAKDOWN.



NEG. No. A-80714 X 3½

PHOTOMICROGRAPH, LONGITUDINAL VIEW OF 5 WIRES SHOWING NUMEROUS LONG SLIVERS.

NEG No A-80715 ×100

MICROSTRUCTURE, LONGITUDINAL VIEW UP TO THE SKIN OF SLIVERED SURFACE SIDE.

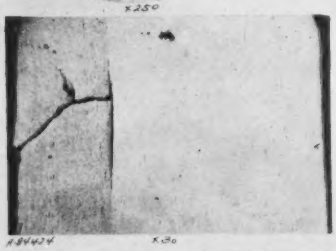
Figure 11. Ruptures in Copper Wire. * *

NEG. No. A-84433 ×250

COPPER WIRE
0.119" Dia. DRAWN FROM ¼"

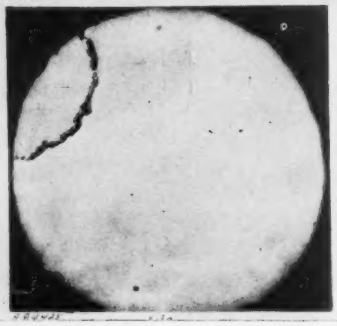


MICROSTRUCTURE, LONGITUDINAL VIEW, UNETCHED SHOWING THE START OF A FAILURE AND THE SEGREGATION OF OXIDE.



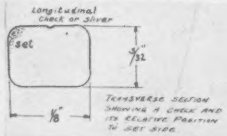
A-84434 ×250

LONGITUDINAL VIEW, UNETCHED SHOWING THE START OF A FAILURE AND ITS RELATION TO THE "SET SIDE"

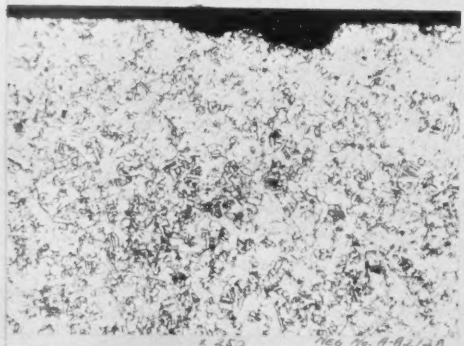


TRANSVERSE VIEW, UNETCHED SHOWING THE RELATION OF THE FAILURE TO THE SET SIDE.

Figure 12. Slivers in Wire Surface. * * —

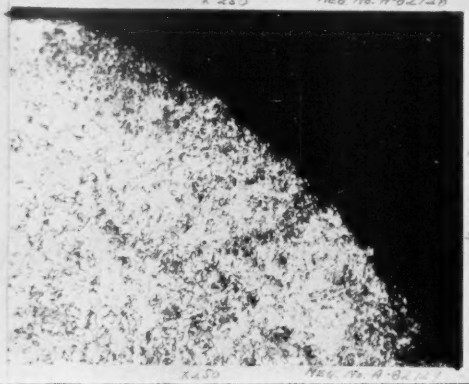



RETANGULAR (3/32" X 1/8") COPPER WIRE SHOWING SLIVERS ON THE SURFACE.



MICROSTRUCTURE, TRANSVERSE VIEW THROUGH A SURFACE SLIVER.

NEG. No. A-82128



MICROSTRUCTURE, TRANSVERSE VIEW SHOWING THE "SET SIDE". SEE DIAGRAM FOR LOCATION.

surfaces is very detrimental, as the particles may be picked up by the varnish or enamel applied to wire, which will lower the dielectric strength of the insulating wall.

✦ ✦ ✦

THEREFORE, conductors must be drawn, rolled and machine scoured, to remove microscopic burrs, slivers, and copper dust before insulating. This practice minimizes the possibility of excessive mechanical and dielectric stresses in the conductor insulation, which might cause failure. Experience has proved that thorough cleaning of conductors, especially for use in transformers, is vital.

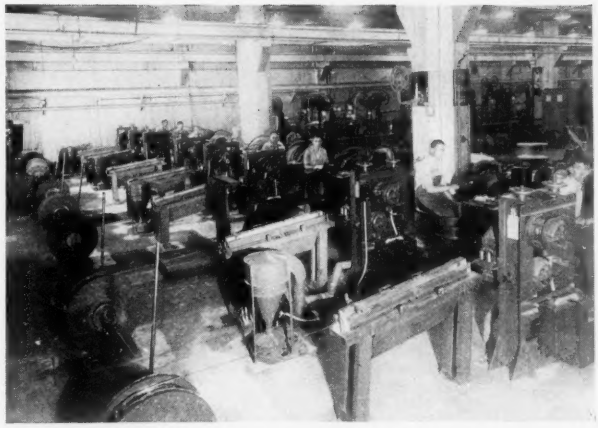


Fig. 13. Wire Scouring and Cleaning Devices.

✦ ✦ ✦

## Improvements by Rod Mills

FOR many years, the electrical manufacturers have used every device known to rid copper of these dangerous imperfections. We now ask for full cooperation of the copper suppliers to improve the quality of the wire bar and the hot rolled rod.

✦ ✦ ✦

SCALPED copper is not the remedy, although in some cases, it is of value. Even using scalped copper, it appears that the copper rod may be hot rolled in such a manner as to produce many dangerous surface slivers and variable grain structure of copper.

✦ ✦ ✦

GRANTED that the supplier can economically eliminate a large percentage of imperfections in the hot rolled rod, the manufacturer of electrical apparatus will then be able to take advantage of this improvement. Substantial reductions in size and cost of electric apparatus may be made, coupled with increased efficiency, without jeopardizing the reliability or reducing the present factor of safety in the insulation.

✦ ✦ ✦

## Radical Improvement in Rod

FOR many years, the electrical industry has been making rapid progress. This is indicated by the steadily rising curve of weekly output of light and power and by the gradual growth in the size of the power transformers as well as the rapid increase in transmission voltage. Refer to Chart 1 and note that in a short span of thirty years, the unit transformer voltage has risen to 287,000 volts, now operating from Boulder Dam to Los Angeles. (See Figure 14).

✦ ✦ ✦

IN the years gone by, outstanding improvements in the electrical industry are:

**The use of silicon steel which is non-aging, with low loss.**

**The development and application of the shielded winding transformer, which has meant the successful transmission of power at very high voltages.**

**The application of Pyranol, the non-explosive and non-flammable insulating and cooling liquid now used, and many other improvements on various types of electrical apparatus.**

✦ ✦ ✦

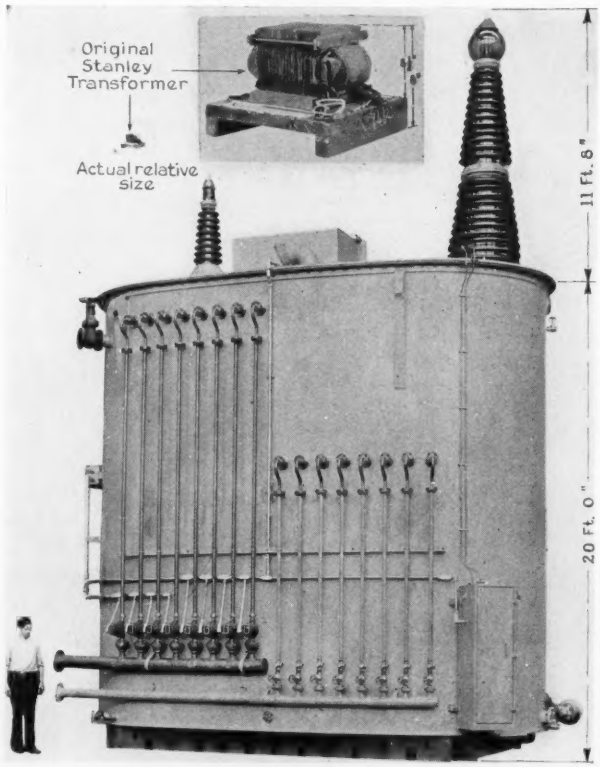



Fig. 14. Original Transformer Built by William Stanley in 1886, and Boulder Dam Transformer Built in 1936.

✦ ✦ ✦

THE electrical manufacturers are now seeking an outstanding improvement in copper wire, which would compare in value to the gains obtained by the use of silicon steel, shielded winding transformers, and the adoption of Pyranol. We would like hot rolled rod from which a better quality of copper wire can be manufactured. What can the copper suppliers accomplish along this line?

✦ ✦ ✦

THE author of this paper is primarily interested in transformer design and manufacture. The same requirements for a better quality wire exist in practically all types of electrical apparatus.

## Why?

More than 225 carefully-prepared exhibits of leading industrial organizations.

More than 145 authoritative up-to-the-minute technical papers.

More than 10,000 of your fellow metal men in attendance.

5 days rich with opportunity for education, relaxation and stimulating contacts .... an opportunity to refill the think-tank with brand-new, high power energy.

They're coming from everywhere .... from every state in the nation where metal is produced or fabricated .... and from other countries, too.

If you have a metal problem — bring it with you to the National Metal Congress and Exposition in Atlantic City, October 18-22. During the five-day Congress you will be able to discuss it with outstanding metal authorities — men who know the latest word in answer to the problems met in the manufacture, treatment, fabrication, testing and inspection of metal.

More people than ever before will attend the 1937 Show and Congress at Atlantic City. They will return this year with new questions because they know that every Metal Show is packed with worthwhile ideas and helpful information.

For complete program, address American Society for Metals, 7016 Euclid Avenue, Cleveland, Ohio.

For hotel reservations write to William B. Coleman, Chairman, Committee on Hotels, 16 Central Pier, Atlantic City, New Jersey.

Sponsored by
THE AMERICAN SOCIETY for METALS

October 18-22
ATLANTIC CITY AUDITORIUM

# NATIONAL METAL SHOW

AMERICAN INSTITUTE of MINING & METALLURGICAL ENGINEERS
THE WIRE ASSOCIATION

COOPERATING SOCIETIES

AMERICAN SOCIETY of MECHANICAL ENGINEERS
AMERICAN WELDING SOCIETY

# Production of Copper From Mine To Mill

By Wm. H. Bassett, Jr.,
Manager, Metallurgical Development,
Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y.

**A discussion of the refinements and improvements made in physical characteristics of copper in recent years to produce better copper wirebars.** ✦ ✦

THE question has often been asked—"Where does the copper come from that is used in making wires and cables and how uniform is it?" In 1845 the total production of copper in the United States was 100 tons. The metal was obtained from five states along the eastern seaboard, namely, Vermont, Pennsylvania, Virginia, North Carolina and Georgia. By 1880 Michigan was producing over 80% of the production in the United States. Ten years later we find Montana exceeding the Michigan production. During the past 25 years Arizona has been the state which has produced the largest amount of copper.

✦ ✦ ✦

TABLE A shows the smelter production of some of the important copper producing states.

✦ ✦ ✦

IN 1850 the first commercial production of fire refined Lake copper was started. The uniform high quality of the Lake Superior ores permitted the refineries to produce a copper which became the standard of the American industry. The uniformity of fire refined copper was to a large extent dependent upon the grading and selection of the ores used in producing the metal. Some mines produce ore carrying small amounts of impurities that are of use in hardening and toughening the copper. By far the greater proportion of the copper ore mined contains impurities which would prevent it from meeting the ASTM specifications for high conductivity wirebars, unless these impurities were removed by electrolytic refining. Fortunately most ores contain precious metals which are separated at the same time and make this removal of injurious elements profitable.

✦ ✦ ✦

IT was not until 1883 that the first electrolytic copper was produced by the Balbach Smelting and Refining Co. The smelting and electrolytic refining methods developed by the American producers have reduced the impurities in copper to a minimum, with the result that the electrolytic copper has been very uniform in quality.

✦ ✦ ✦

TYPICAL analyses of three common present-day grades of copper are given in table B.

**TABLE A TONS PRODUCED**

| | 1880 | 1885 | 1895 | 1905 | 1915 | 1925 | 1935 |
|---|---|---|---|---|---|---|---|
| Arizona | ..... | 11,353 | 23,977 | 113,427 | 216,234 | 361,327 | 139,260 |
| Montana | ..... | 33,899 | 95,086 | 157,375 | 134,131 | 135,302 | 78,880 |
| Utah | ..... | 63 | 1,092 | 27,042 | 87,589 | 121,365 | 60,486 |
| Michigan | 24,868 | 36,074 | 64,665 | 115,144 | 119,478 | 69,015 | 36,906 |
| Nevada | ..... | 4 | ..... | 207 | 33,879 | 38,569 | 36,409 |
| Alaska | ..... | ..... | ..... | 2,450 | 35,343 | 36,102 | 7,301 |
| New Mexico | ..... | 40 | 72 | 2,667 | 31,408 | 38,234 | 2,230 |
| California | ..... | 235 | 109 | 8,349 | 18,829 | 23,472 | 815 |
| Colorado | ..... | 573 | 3,040 | 4,702 | 3,636 | 1,582 | 7,170 |
| Total for U.S. | 30,240 | 82,937 | 190,307 | 444,392 | 694,005 | 837,435 | 381,294 |

FOR the past 35 years electrolytic copper has been the standard of the electrical industry. The increase in the demand for electrolytic copper is readily shown by referring to table C.

✦ ✦ ✦

THE figures in Table C include the production of copper from imported ores or "blister" from such countries as Chile, Mexico, Peru, and Canada. For a considerable period of time at least 90% of the primary production of copper has been in the electrolytic grade.

✦ ✦ ✦

WE sometimes hear the statement made that the quality of copper is not as good as it was thirty or forty years ago. Such statements are indicative of ignorance of the real facts, for the quality of present day copper in the industry has never been exceeded. Wirebars are being produced that materially exceed the minimum of 99.900% (Cu + Ag) and the conductivity is being maintained at or above 100% of the annealed copper standard. There is nothing which has been done in the past with copper which we cannot now do with present day copper.

✦ ✦ ✦

THE physical characteristics of copper caused it to become the most important material in the electrical field. Copper is the metal which has made possible an "Electric Age". It has

a high electrical conductivity. Its extreme ductility, excellent heat dissipating qualities, and high resistance to corrosion are likewise very important to the designer of electrical equipment.

✦ ✦ ✦

ONE of the well known tests which wire mills have made to demonstrate the great ductility of copper has been to draw a one-inch diameter rod until a wire was produced finer than the ordinary human hair. The 99.9996% reduction which the copper receives in cold drawing it to .002" diameter does not in any way injure the ductility of the copper. No annealing or heat treatment whatever is given the material during the drawing operations, and none is needed after finishing. The one inch rod was rolled from standard electrolytic wirebars, and in drawing, its length was increased from one foot to forty-seven miles.

✦ ✦ ✦

THE success of such a demonstration, of course, is dependent upon good heating and rolling technique in the fabrication of the rod and good wire drawing practice, coupled with the use of properly shaped dies, which prevent the types of wire defects described by Mr. H. C. Jennison in his paper entitled "Certain Types of Defects in Copper Wire Caused by Improper Dies and Drawing Practice"*.

✦ ✦ ✦

FABRICATORS of copper have long recognized the fact that the structure of the standard wirebar was not entirely homogeneous. Care had to be taken in the heating of the bars in order to keep the temperature within proper limits so that the set area where there was a concentration of oxides would not be fractured during the hot working. The reason that the fabricators produced satisfactory wires for all industrial requirements can be attributed to the working of the metal by means of gradual reductions.

*Transactions of the American Institute of Mining and Metallurgical Engineers, Institute of Metals—1930 volume.

TABLE B

| | Electrolytic Wirebar | Lake Wirebar | Oxygen Free Wirebar |
|---|---|---|---|
| Copper | 99.955 | 99.937 | 99.985 |
| Oxygen | .033 | .033 | .000 |
| Silver | .0009 | .0216 | .002 |
| Sulphur | .0029 | .0022 | .0025 |
| Arsenic | .0008 | .0024 | .0008 |
| Antimony | .0003 | .0013 | .0028 |
| Nickel | .0002 | .000 | .0016 |
| Iron | .0023 | .0010 | .0015 |
| Tin | .0011 | — | — |
| Bismuth | .00002 | — | — |
| Lead | .0020 | .000 | .0004 |
| Selenium | .0007 | — | .0020 |
| Tellurium | .0012 | — | .0011 |

TABLE C
PRODUCTION OF PRIMARY COPPER IN LAKE AND ELECTROLYTIC GRADES (TONS)

| Year | Lake | Electrolytic |
|---|---|---|
| 1893 | 56,730 | 45,000 |
| 1905 | 109,500 | 380,000 |
| 1910 | 110,700 | 575,812 |
| 1915 | 118,379 | 680,422 |
| 1920 | 76,742 | 730,218 |
| 1925 | 69,015 | 1,075,201 |
| 1930 | 71,493 | 1,039,908 |
| 1935 | 36,803 | 569,924 |

ANOTHER practice which assisted them in developing their high quality product was the use of open fire anneals. In the early days of the industry, fire refined Lake copper wirebars were the standard material which was found in the rolling mill. By 1900 we found in use both Lake and electrolytic tough pitch wirebars. In 1932 the U. S. Metals Refining Co., a subsidiary of the American Metal Co., placed on the market a grade of copper known as OFHC (oxygen free high conductivity). They also produced another type of wirebar referred to as VC (vertically cast) tough pitch copper wirebars. These were followed by the American Smelting & Refining Co.'s "no set" wirebars.

✦ ✦ ✦

IN the paper by **Messrs. W. R. Webster, J. L. Christie, and R. S. Pratt**, entitled **"Comparative Properties of Oxygen Free High Conductivity, Phosphorized, and Tough Pitch Coppers"*** a statement is made that their tests indicate that the oxygen free high conductivity copper is capable of withstanding more severe drawing operations than tough pitch copper. In the paper by **Messrs. Sidney Rolle and P. H. Brace**, entitled **"Oxygen Free High Conductivity Copper—Its Properties and Uses"****, the statement is made that oxygen free high conductivity copper as now manufactured is definitely a more homogeneous and consistent material than is copper of the usual commercial grades.

✦ ✦ ✦

THESE statements arise from the fact that when the set with its concentration of oxides is removed from the surface of the bar, the metal can be worked through a greater range of temperatures without the danger of tearing or

*Transactions A. I. M. E., Vol. 104, Institute of Metals Div. 1933.
**A. I. M. E. "Mining and Metallurgy"—Aug. 1933.

Fig. 1. Copper Wire Bars as Received from Refinery.

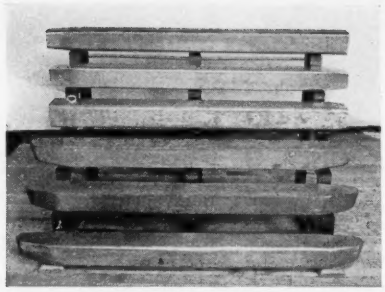


Fig. 2. Various Types of Wire Bars.

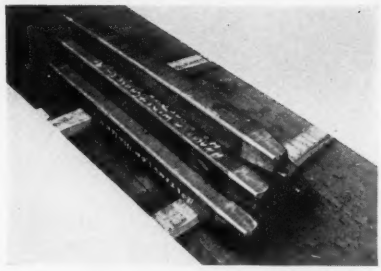


Fig. 3. Double Pointed Vertically Cast Wire Bars.

fracturing the set surface. Thus the more homogeneous bars of the scalped or end poured types lend themselves more readily to the greater reductions, fewer passes, and greater speeds which have become more prevalent in the present-day rod mills.

✦ ✦ ✦

THE oxygen free material was developed to meet the needs of the Transatlantic communication cable manufacturers, who required a copper that could be annealed in hydrogen without becoming brittle. The new developments have complicated the stock which it is necessary for the rod mills to handle in meeting the requirements of their customers. We consequently find today in up to date rod mills, six classes of wirebars, namely—

1) **Fire refined Lake copper**
2) **Standard electrolytic copper**
3) **Scalped electrolytic copper**
4) **End poured electrolytic copper**
5) **Deox'dized copper**
6) **Oxygen free copper.**

IN this latter type is classed not only the OFHC copper, but the coalesced copper produced by the Phelps Dodge organization.

✦ ✦ ✦

FIGURE 1 shows the manner in which standard wirebars are piled for convenience of handling between the refinery and the rod mill. In Fig. 2 six wirebars are shown. Referring to the bars in order from top to bottom, the first bar is deoxidized high conductivity copper. This material has always

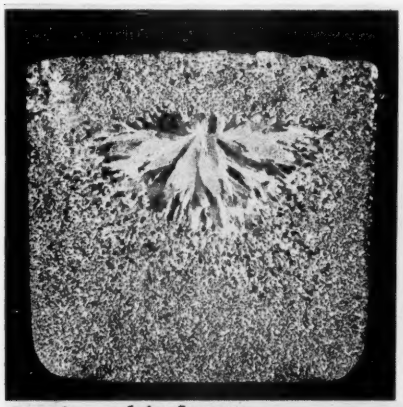


Fig.4 Lake Copper

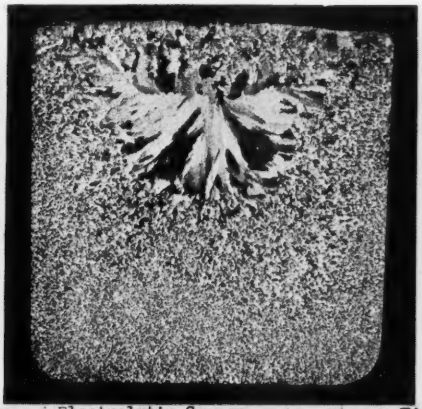


Fig.5 Electrolytic Copper

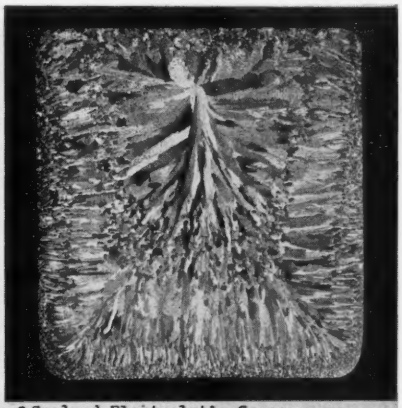
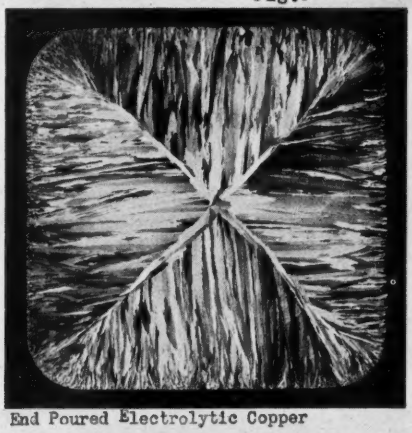
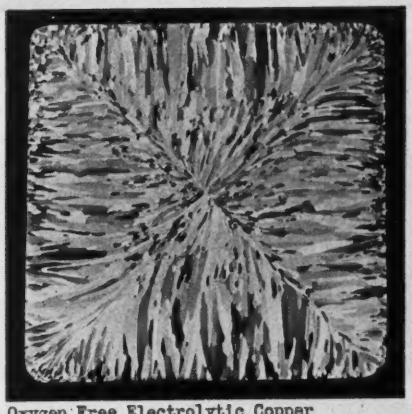


Fig.6 Scalped Electrolytic Copper



End Poured Electrolytic Copper
Fig.7



Oxygen Free Electrolytic Copper
Fig.8

MACRO STRUCTURE OF WIRE BAR CROSS SECTIONS

been cast vertically. The second bar pointed at both ends is OFHC copper. The third bar is end poured electrolytic tough pitch copper. The fourth bar is a standard electrolytic tough pitch wirebar. The upper or set surface has the typical crinkled appearance found in this type of casting. The fifth and sixth bars are two types of scalped standard electrolytic tough pitch copper.

✦ ✦ ✦

FIG. 3 shows a group of the double pointed vertically cast wirebars described by **Mr. Frederic Benard** in his paper published in the September issue of "Wire and Wire Products". These bars have all the advantages of end poured copper, and, in addition, have points at both ends similar to a standard wirebar which is of decided convenience in the hot rolling operation.

✦ ✦ ✦

FIGS. 4, 5, 6, 7, and 8 show the relative macro structures of cross sections of 5 grades of wirebars, namely: Fire refined Lake, standard electrolytic, scalped electrolytic, end poured electrolytic, and oxygen free. The first four types are classed as tough pitch coppers. In the refining of copper, an excess of oxygen is introduced into the metal to eliminate absorbed gases. This so-called dry or "set" copper is then reduced by "poling", or agitating the molten charge with green wood poles. The surface of the metal is protected from the furnace atmosphere by a layer of charcoal. The oxygen content of the metal is reduced to approximately 0.04%. Experience has shown that at this point the cast metal has its greatest toughness when a test specimen is broken with a sledge.

✦ ✦ ✦

THE technical details of the concentration of the copper ore, the smelting, refining, casting, and rolling, were described by **R. H. Miller and W. S. Adams**, in their paper entitled **"Smelting, Casting, and Rolling of Electrolytic Copper"***.

✦ ✦ ✦

EXHAUSTIVE tests in various laboratories have shown that the ordinary tensile strength and elongation tests do not have the required sensitivity to show the difference between the various grades of copper wirebars. The materials, however, can be readily identified by microscopic examination.

✦ ✦ ✦

FIGS. 9, 10, and 11 show the macro structure at a magnification of 10 diameters of cross sections of rods rolled from three types of wirebars. Figs. 12, 13, and 14 give the detail of the edge of these same rods at a magnification of 100 diameters.

✦ ✦ ✦

IN Fig. 12, the portion of the hot rolled rod section shown contains an edge which corresponded

*"Wire and Wire Products"—Sept., 1934.

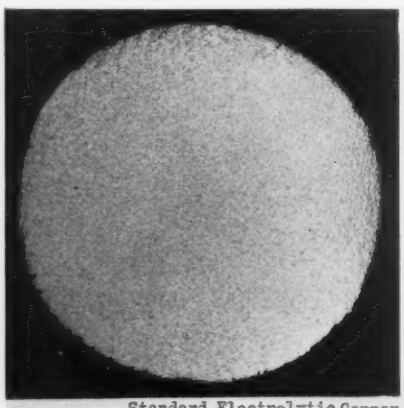


Fig.9 Standard Electrolytic Copper

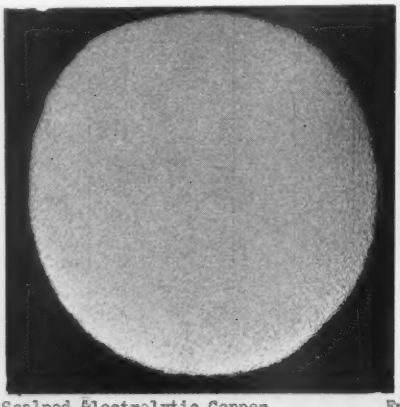


Fig.10 Scalped Electrolytic Copper

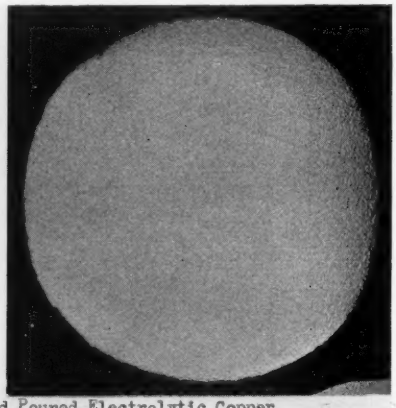


Fig.11 End Poured Electrolytic Copper

Macro structure at magnification of 10 diameters of cross section of rods hot rolled from wire bars.

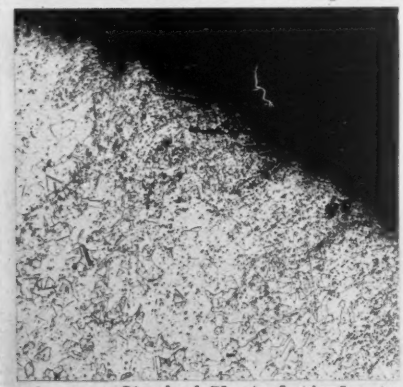


Fig.12 Standard Electrolytic Copper

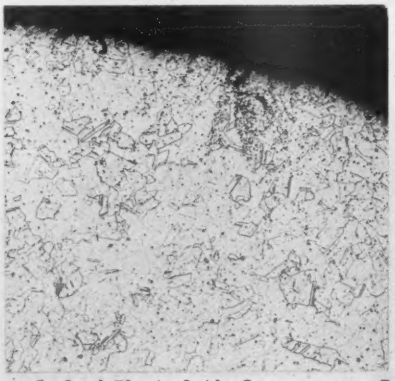


Fig.13 Scalped Electrolytic Copper

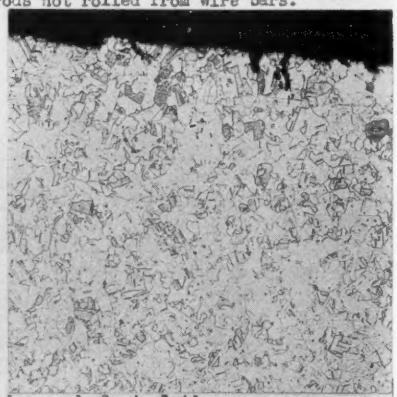
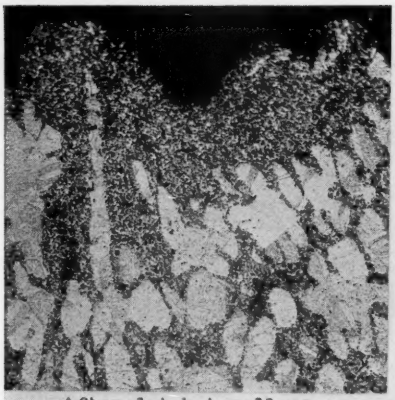
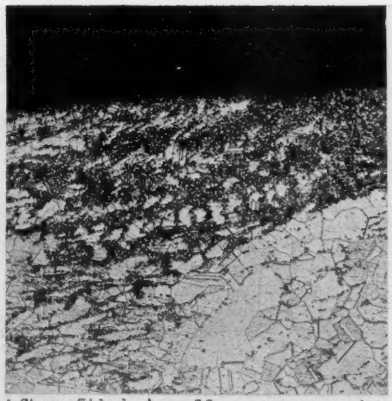


Fig.14. End poured electrolytic copper

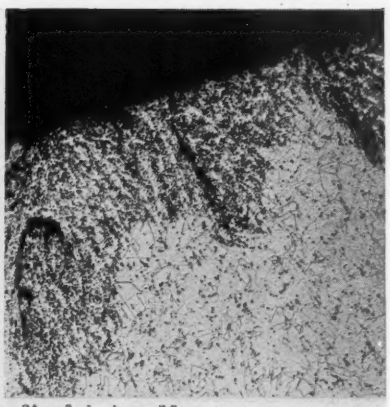
Detail of top edge at magnification of 100 diameters of hot rolled rod sections shown above.



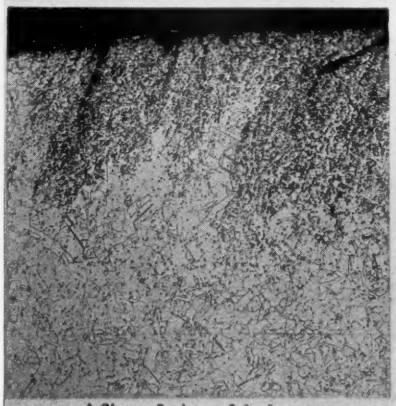
After 1st hot roll pass.
Fig.15



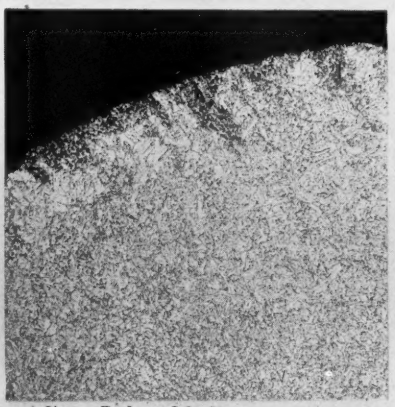
After 5th hot roll pass.
Fig.16



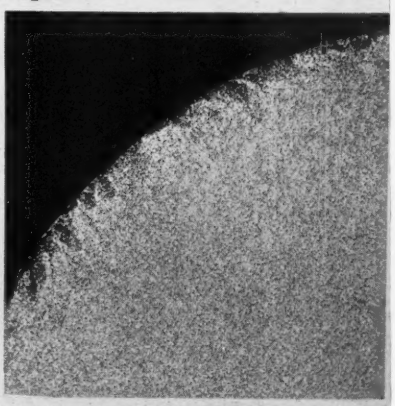
After final hot roll pass.
Fig.17



After 1st cold draw.
Fig. 18



After 3rd cold draw.
Fig.19



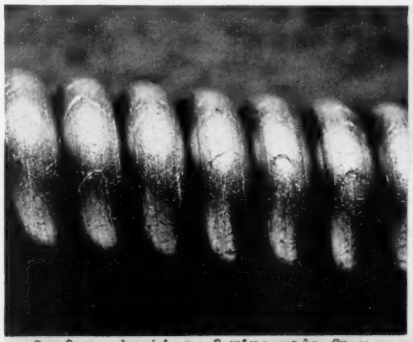
After final cold draw.
Fig.20

DETAIL OF STRUCTURE AT SET EDGE OF STANDARD ELECTROLYTIC COPPER BARS AND WIRES IN VARIOUS STAGES OF MANUFACTURE.
MAGNIFICATION 100 DIAMETERS

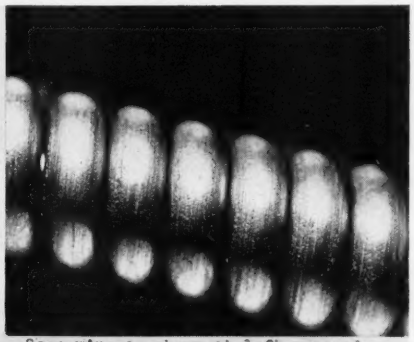
with the set surface of the wirebar. Likewise in Fig. 13, the edge shown corresponded with the scalped surface of the wirebar. Fig. 14 shows the average edge condition of the hot rolled rod. All sides of the end poured casting being similar, there was no marked difference in appearance of various portions of the periphery of the rod when examined under the microscope.

✦ ✦ ✦

THE cuprous oxide concentration in

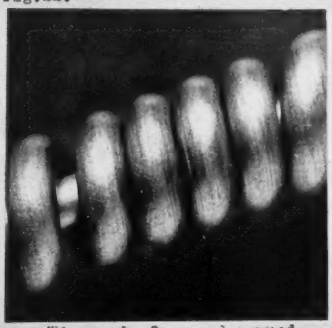


Surface checking of wire made from standard electrolytic copper.
Fig.21.



Same wire as shown at left wrapped with opposite surface exposed.
Fig.22.

Wire made from scalped electrolytic copper.
Fig.23



Wire made from end poured electrolytic copper.
Fig.24

TYPICAL APPEARANCE OF WRAP SPECIMENS OF .104" DIA. HARD WIRE MADE FROM VARIOUS TYPES OF ELECTROLYTIC COPPER WIRE BARS. MAGNIFICATION 5 DIAMETERS

the set surface of a standard wirebar can be traced through each of the steps in the hot rolling mill, and can be located after the rod has passed through the successive dies in the wire drawing operations.

✦ ✦ ✦

FIGS. 15, 16 and 17 show the appearance of the set area respectively after the first, fifth, and final hot rolling passes in the rod mill. Figs. 18, 19 and 20 show the appearance of the set area of

Every inch a perfect specimen. Every mile for that matter, because Keystone wire is notably uniform . . . the same in your tenth order as in your first.

And as to performance . . . well, Keystone wire **must** perform for you! If none of the stock sizes, analyses and finishes precisely meet your requirements, Keystone's technical staff will create a wire that does. Write . . . maybe Keystone wire can lift a load off your mind!

KEYSTONE
STEEL and WIRE COMPANY
**Department W** **Peoria, Illinois**

SAMSON SPRING WIRE
KEYSTONE STEEL & WIRE CO. PEORIA, ILL.

**HIGH CARBON or LOW CARBON**
**Bright . . . Tinned**
**Coppered .. Annealed .. Galvanized**

the same rod after passing through the first, third and final wire drawing die. These pictures were taken at a magnification of 100 diameters in order to bring out the structural details.

✦ ✦ ✦

THE surface of a wire corresponding with the set side of a wirebar does not have as great ductility as other portions of the surface. This fact is readily illustrated in Figs. 21 and 22, where the same .104″ diameter hard copper wire has been wrapped around its own diameter. The surface checking of the side containing the set area corresponding to the condition shown in Fig. 20 can be readily noted. When the opposite side of the wire was exposed during the wrapping operation, complete freedom from checking will be noted, as shown in Fig. 22. The photographs were taken at a magnification of 5 diameters.

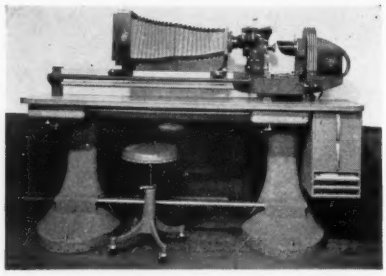


**Fig. 25. Metallurgical Microscope and Camera Used in Development Work.** ✦ ✦

IN the case of wire drawn from rods made from scalped wirebars and end poured wirebars, these differences in surface ductility are not found, as illustrated by the freedom from checking of wires wrapped around their own diameter shown in Figs. 23 and 24.

✦ ✦ ✦

AS intimated above, the laboratory investigator can readily determine the grade and type of copper used in the production of a piece of wire by the use of the spectroscope and microscope. The metallographic examination will not only indicate the type of wirebar used, but will also show whether good rolling and drawing technique has been used in the fabrication of the product.

# Notes On The Annealing of Nickel Silver Wire In Coils

By Thurston C. Merriman,
Metallurgist, Seymour Manufacturing Co.,
Seymour, Conn.

**Some notes based on past experience of certain phases of annealing nickel silver wire which may be of value to the industry as a whole.** ✦ ✦ ✦ ✦

THE following notes are gleaned in part from the experience of a manufacturer engaged in producing Nickel Silver Wire for more than sixty years, and are presented as a contribution of possible interest to various members of this Association, and as a starting point for discussion rather than as anything like the last word. If we seem to be a bit dogmatic in spots we are not so by intention but simply because certain phases of this subject have been quite forcibly impressed on us by that best but most costly of teachers, Lady Experience.

✦ ✦ ✦

NICKEL Silver Wire is normally produced with nickel content from five to thirty per cent, with copper content from around fifty per cent up to seventy five, with zinc as the balance except for small quantities of deoxidizers such as manganese or magnesium and occasional small amounts of other elements added for a special purpose such as lead to promote ease of machining. Details of melting and casting practice as well as of the early cold rolling are outside the scope of this paper. When the wire rod is coiled at the last pass through the cold rolls it becomes in common parlance "wire in coils" and it is with the annealing from this stage on that we are concerned.

✦ ✦ ✦

## Types of Annealing Furnace

FURNACES for the annealing of Nickel Silver Wire in Coils can be roughly classified in four groups, viz:

A. Muffle type.
B. Salt Bath.
C. Water Seal.
D. Bell type.

## A. Muffle Type

MUFFLE furnaces may be either electrically heated, or fuel fired. In an electrically heated muffle furnace the wire may be introduced in the same condition as it comes from the die, or it may be given a protective coating, such for example as a mixture of boracic acid and ochre. In the latter instance an almost bright anneal can be obtained by dissolving and rinsing off the protecting agent after the metal has cooled.

THURSTON C. MERRIMAN

A native of Bristol, Connecticut; Graduated from Massachusetts Institute of Technology, Department of Mining Engineering, in 1909. For several years thereafter he was Assistant Metallurgist in the Technical Department of The American Brass Company. 1915-1921 with Winchester Repeating Arms Co., Cartridge Department on development work and as Assistant Inspection Supervisor and Metallurgical Engineer. Then followed a year in the Development Branch of the Western Electric Company at Hawthorne and seven years as Metallurgist at the Western Cartridge Company. In 1929 returned to the Western Electric on development work, which he left to take his present position as Metallurgist, Seymour Manufacturing Company, in the fall of 1929.

It is probable that a well designed and properly constructed electrically heated muffle furnace is capable of giving a more uniform and better controlled anneal than a fuel fired furnace, but it is open to question whether these advantages are worth what they cost except in the case of extremely rigid specification requirements where cost is of lesser importance than in ordinary commercial production work. In some instances of course, appreciable narrowing down of variation is worth considerable extra cost, and under such conditions the electrically heated muffle furnace would seem more desirable.

✦ ✦ ✦

FUEL fired furnaces may use either oil, gas, coal or wood as the source of heat. They may be under-fired as in the Rockwell type, or may have a combustion chamber along the side or at the end, with the products of combustion coming over a baffle wall; or the combustion chamber may completely surround the muffle as in some comparatively small American Gas furnaces. The under-fired oil-burning type of furnace does a very good job, but it is essential to have the fuel oil very low in sulphur, and this is sometimes difficult to obtain. The type of burner is important, for it must give good heating efficiency, and at the same time be quite flexible to permit the necessary control of atmospheric conditions within the furnace. Atomization of the fuel oil can be accomplished either by steam or by air and each way has its advantages.

✦ ✦ ✦

NICKEL Silver may pick up sulphur from products of com-

# MODERN THOUSAND-LEAGUE BOOTS

If a man had magic boots capable of covering 1000 leagues at a stride, it would still take him many weeks each year to see the most important developments in the metal industry. In five days at the National Metal Show he can see them all—and that's no fairy story!

By spending five days at Atlantic City in October you will see displays of more than 225 leading industrial organizations . . . actual operating exhibits of newest developments in plant and research equipment . . . every aisle in the huge auditorium packed with ideas in metal research, production and equipment . . . every exhibit manned by metal experts welcoming questions about their products.

In addition, you can hear any of the more than 145 authoritative technical papers to be presented at the Congress sessions of the five great technical societies co-operating in the Congress. Prepared by outstanding authorities, these papers background the practical production lessons of the Exposition with the up-to-date technical information so vital to success in today's metal industry.

For complete program, address American Society for Metals, 7016 Euclid Ave., Cleveland, Ohio.

Make your preparations for National Metal Show now . . . don't forget that every step you take at the Show will be like walking in "thousand-league" boots! For hotel reservation write Wm. B. Coleman, Chairman, Committee on Hotels, 16 Central Pier, Atlantic City, New Jersey.

Sponsored by
THE AMERICAN SOCIETY for METALS

October 18-22
ATLANTIC CITY AUDITORIUM

# NATIONAL METAL SHOW

AMERICAN INSTITUTE of MINING & METALLURGICAL ENGINEERS
THE WIRE ASSOCIATION

COOPERATING SOCIETIES

AMERICAN SOCIETY of MECHANICAL ENGINEERS
AMERICAN WELDING SOCIETY

bustion without much provocation, and likewise at a high temperature anneal is capable of absorbing considerable carbon from any contact with carbonaceous matter, whether gas, fluid, or solid. This latter absorption is usually in the form of nickel carbide, which in itself may be comparatively harmless, but after another anneal, nickel carbide is likely to break down with separation of carbon in the form of graphite flakes, especially at the grain boundaries. After this has taken place, further cold-rolling may result in internal ruptures starting at the location of these graphite flakes, with breakup of the material naturally ensuing. From the standpoint of freedom from sulphur and slow, gentle heating, wood is probably the best fuel available, and for many years it was not considered possible to do a good job of annealing with any other fuel. We doubt, however, if wood is largely used for this purpose at present, and certainly exactness of annealing requirements is greater today than ever before. We feel that the baffle type of furnace mentioned above is less desirable than the under-fired both on account of the comparatively greater difficulty of obtaining uniform heating conditions and because of the greater danger of contact of the flame itself with the work to be annealed.

✦ ✦ ✦

ANY of these furnaces can be used for what might be called "protected" annealing. We mean annealing where the coils are enclosed in a more or less well sealed container and these containers drawn into the furnace on pans or conveyors, the idea being to largely prevent the formation of scale or oxide. These protectors may take the form of cast iron pots with the covers sealed down with fire-clay, or one pan inverted over the other with finely-divided charcoal or sand or metal scale to seal the junction, or the coils may be well packed in fine charcoal in a tube or in or under a pan. So far as we know none of these devices permit omission of an acid cleaning on finished wire, although they may permit such an omission for intermediate draws. By minimizing the acid requirement they do go a long way to help in keeping the size on finished fine wire. They also do notably increase the time necessary for a given anneal, and uniformity is likely to suffer unless the utmost precautions are rigidly observed. Such an anneal is used for certain special jobs but it is not largely used for the general run of work. Of course any of these furnaces should have a good pyrometer installation which is kept well checked. This is another reason why we are not partial to the baffle type, because it is very difficult in such a type of furnace to get a pyrometer installation which is not unduly subject to difficulties from the naked flame, and no empirical formula will give correct results when a naked flame plays on or almost upon a pyrometer fire-end.

✦ ✦ ✦

### B. Salt Bath

A GOOD salt bath installation lends itself very nicely to the annealing of a comparatively few coils of Nickel Silver wire at a time. The time of heating is much shorter than that necessary for a muffle load, and this compensates to quite an extent for the smaller sized charge. On the other hand it is rather expensive to operate, is sort of a disagreeable job, and there is likely to be a little variation in temperature from top to bottom of the rack as it is immersed in the bath, though no more than nor even as much as the variation in different parts of a muffle load; however, this slight variation can largely be avoided by careful manipulation.

✦ ✦ ✦

A SALT bath for this work should have a fairly wide working range, e. g. from twelve hundred degrees Fahrenheit to fourteen hundred and fifty degrees Fahrenheit. It should be thoroughly fluid over the working range, and must not have a noticeably corrosive action at the working temperatures on the metal to be annealed. It should also be readily soluble in water when cold, otherwise altogether too much difficulty will be had from snarling and sticking, especially where fine wire has been annealed in the salt bath and then quenched in water, as is the common practice. In one setup the salt mixture is contained in a large iron pot set into a brick furnace with short flame oil burners supplying the heat through the combustion chamber. The coils are carried into and out of the bath on an upright pin rack by means of a compressed air hoist. Each furnace has a quenching and a rinsing tank adjacent. Very little acid cleaning is needed after an anneal in the salt bath and the quality of work that comes from it is excellent.

✦ ✦ ✦

### C. Water Seal Furnaces

THIS type of furnace is popular in some quarters for annealing Nickel Silver wire in coils. We don't intend to discuss it at great length for the reason that there are a number of features about it that do not appeal to us for use with Nickel Silver wire.

✦ ✦ ✦

IN this type of furnace the charge is loaded on a platform, then passes through a water seal and into the heating chamber. Here the heat may be applied either electrically or by fuel-fire. After the prescribed time at temperature in the furnace the charge is removed through a water bath where it is quenched to the boiling point of water or somewhat above, depending on the length of time it remains in the water bath, and comes out to the air. We understand that wire annealed in this manner always requires at least a light pickling, although there is by no means a heavy scale formed. To our way of thinking the confinement and restriction incident to packing of the charge if anything approaching to economy is to be obtained, is not desirable with an alloy that is so comparatively sensitive to fire-cracking as is Nickel Silver. This same confinement would seem to render the quenching after the anneal a source of considerable danger. Also we are not too sanguine over ability

to obtain repeated uniformity of anneal in a charge heated under the conditions mentioned and with no line on what is going on in the heating chamber except such information as can be gained from a pyrometer with its fire-end embedded in the wall of the heating chamber. We have no special argument with this type of furnace as a general proposition, but it simply does not appeal to us for the annealing of Nickel Silver wire in coils.

✦ ✦ ✦

### D. Bell Type

THIS type of furnace is one in which the coils of wire to be annealed are enclosed in a metal or metal and refractory retort shaped somewhat like a bell, whence the name, Bell type furnace. An excellent example of this type is the General Electric, where the work is piled on a platform with a central heating element and then the bell retort with electric heating elements in the side walls is brought to the platform and settled down on it, forming a tight enclosure. Provision can be made for the ingress and egress of gas to prevent oxidation during the heating and cooling, and thus avoid or minimize subsequent pickling. Of course the heat control in such a furnace is excellent. We understand that a good clean anneal can be obtained in such a furnace and much is to be said for the uniformity of anneal and ease of control that is possible with this equipment.

✦ ✦ ✦

WE just mentioned "clean" annealing and this term was used purposely rather than "bright anneal". Although many attempts have been made, we are not personally familiar with any equipment which will consistently give a "bright anneal", as we understand the term, to Nickel Silver wire in coils. We have seen occasional instances where a coil or coils have had what might pass for a bright anneal, but this accomplishment has not proved to be reproducible at will with complete uniformity in color and brightness throughout all coils.

### General Considerations

IN considering the annealing of Nickel Silver Wire in coils there are a number of general features to which we would invite your attention for a few moments, since a correct knowledge and wise application of that knowledge would probably make the difference between success and failure in attempting the operation.

✦ ✦ ✦

### Slow Heating Desirable

IN the first place we do not consider that it pays to try to hurry the job. We believe in giving plenty of time at a comparatively low temperature rather than work at high furnace temperatures with the resultant need to catch the work "on the fly". The latter practice is rather deadly to uniformity and may easily cause the ruination of what might otherwise be perfectly good metal. The velocity of grain growth in Nickel Silver is much slower than that of common high brass for example. It does not commence as early in the heating cycle and it proceeds more slowly after it does begin. This fact is one reason why we consider it much better to let a load of nickel silver coils soak for some time after reaching the temperature of the furnace rather than remove the charge as soon as it is apparently up to heat. Much better uniformity of behavior in subsequent fabrication usually follows a proper soaking anneal than is found in a lot of wire which has been removed from the furnace as soon as it reaches proper heat. The latter practice is of course more economical but we do not consider it advisable in the long run.

✦ ✦ ✦

### Avoid Heat Shock

ALONG with the idea of slow heating we would submit that it is desirable to avoid heat shock so far as possible in annealing Nickel Silver. That is, it is better to pull a load into a furnace at comparatively low temperature and let it heat slowly for awhile from the heat residual in the furnace before actively raising the furnace temperature to that at which it is desired to let the load of metal soak. Conversely, slow cooling is likewise desirable, in some instances to an extent such that precautions should be taken to see that the load of hot metal is not exposed even to draughts of cool air for quite some time after it comes out of the furnace. It is true that a quench in a water bath usually follows right after a salt bath anneal, but this is for other considerations rather than because of any beneficial effect of the quenching on the physical properties of the wire. As a matter of fact there are some reasons for the belief that quenching has a deleterious rather than a beneficial effect on Nickel Silver.

✦ ✦ ✦

### Time Requirements

THE time required for a satisfactory anneal will naturally vary with the load going into the furnace. In this connection another word of caution may not be amiss. Although from the standpoint of heating efficiency and economy, large loads may be preferable to small, it should be borne in mind that the manner of piling or arrangement of the coils not only has a very vital bearing on the uniformity of softening through different parts of the load, but also is of unusual importance in handling an alloy so subject to fire-cracking as is Nickel Silver. We have in mind the perfectly natural tendency to pack a load tightly in order to get more metal treated in a given space. Such tight packing may take the form of binding the loops of each coil to keep it in a small space or the piling of one coil on another so that any possible movement of the coils underneath is restricted by the super-imposed weight. Either one of these things is a cordial invitation to fire-cracking and can be fairly well depended upon to produce it if other conditions are favorable.

✦ ✦ ✦

### Temperatures

THE matter of temperature of anneal depends on many different factors, for example, composition of the alloy whether high

or low copper and whether high or low nickel, although the percentage of nickel has perhaps a greater influence on the time required than on the temperature. The temperature of the preceding anneals and the amount of cold work done on the wire since the last anneal are also of importance in determining the proper annealing treatment. If there is a grain size specification for the stock at shipment, this must also be considered and frequently will exercise a control on one or more anneals before the last. If the wire is to be shipped in the soft annealed state it is necessary to make proper allowance for loss in diameter through pickling and cleaning, and this factor is closely tied up with the type of furnace to be used for the finish anneal.

+ + +

## Leaded Nickel Silver

THE above remarks apply to both non-leaded and to leaded Nickel Silver but some of them should be emphasized in dealing with leaded stock. With such an alloy we are frankly between the devil and the deep sea. We need heat and time on account of the nickel content and the slow velocity of grain growth; and on the other hand, excessive temperature or too long time tends toward segregation of the lead, more particularly at the grain boundaries, which is frequently followed by failure in subsequent working. The very manner in which lead enhances the value of the alloy for certain purposes such as ease of machining also causes failure where too much pressure causes the segregated lead to function as a metallic lubricant.

+ + +

ONE way particularly in which the addition of lead makes Nickel Silver more difficult to manufacture lies in the greatly increased sensitiveness of the lead-bearing alloys to rapid changes in temperature. This requires several changes in practice as compared with non-leaded wire. Among these are the following:—

**a) Slower rate of heating as well as slower rate of cooling.**

**b) Loading in such a manner as to insure greater freedom of movement of the individual strands as the heat strikes them.**

**c) Special precautions to avoid cool draughts until cooled considerably below any suspicion of redness.**

**d) See that sufficient cold work is done between anneals; in other words make sure that the drawing layout is designed with an eye to fire-cracking possibilities.**

**e) Thorough springing should be done before each anneal. And when we say springing we mean just that. Rolling over a barrel to a different coil radius is not what we call springing, though perhaps some people do. We mean forcible reversal of direction of curvature of the wire axis and of all fibers parallel to it.**

+ + +

THESE last matters are not mentioned with the idea of a treatise on fire-cracking, although this is a decidedly important subject when considering Nickel Silver and one about which we feel altogether too little is known. They are mentioned because of our conviction of the necessity for their observance if success is to be had; and in amplification of item "e" we might mention our belief that the **direction** of the internal stresses resulting from cold work is fully as important as their **intensity,** in their bearing on liability to fire-crack.

+ + +

IN this paper we have endeavored to present a picture of the subject as we see it. We realize we have expressed a number of opinions that may be considered of debatable soundness, and we shall be happy if discussion arises therefrom.


| FOR | THE CLEANING HOUSE . . . . . HOT GALVANIZING ROOM . . . . . ELECTRO GALVANIZING ROOM . . . |
|---|---|
| Hot or Cold Muriatic ● Hot or Cold Sulphuric ● Abrasion Resistance ● | DURIRON and DURICHLOR EQUIPMENT<br>Centrifugal Pumps—standard and self-priming.<br>Valves—"Y", Angle, Check, Quick-Releasing, Duriron-Nordstrom lubricated.<br>Tank Outlets—Heating Coils for Cleaning Tubs—Pipe and Fittings for Acid Handling—Acid Resisting Tank Fittings—Pickling Crates—Yokes—Heat Exchangers—Heating Jets.<br>WILL REDUCE COSTS, SAVE TIME, IMPROVE RESULTS<br>*Write for bulletins on acid handling equipment*<br>The Duriron Company, Inc.<br>445 N. FINDLAY ST. DAYTON, OHIO |

# Nickel And Nickel Base Alloys In Wire And Rod Products

By Carl Rolle,
Development and Research Division, The International Nickel Co., Inc., New York, N. Y.

A study of the corrosion resisting properties of nickel and nickel base alloys in the form of wire and rod, together with an outline of the essential working characteristics required for the satisfactory manufacture of such products.

THIS paper covers the physical and corrosion resisting properties of the following materials in wire and rod form, together with the essential working characteristics as affecting the manufacture of wire and rod products:

**1—Monel, regular type.**
**2—"R" Monel, free machining type.**
**3—"K" Monel, heat treatable type.**
**4—Nickel, regular type.**
**5—"Z" Nickel, heat treatable type.**
**6—Inconel, nickel-chrome-iron alloy.**

✦ ✦ ✦

THESE are among the most important and the most generally used of the high nickel wrought materials. Although the greatest tonnage of material used in the construction of corrosion resisting equipment is in the form of plates or sheets, it is equally or more important to consider some special aspects of the corrosion problem in connection with parts made from wire and rod stock. These are:

**1—Most plate and sheet is corrosively exposed on one side only, while parts made from wire or rods are usually exposed over their entire surface. Thus, if a 1 inch plate is corroded to a depth of 0.1 inch on one side only, the cross section is reduced by 10 per cent; whereas, if a 1 inch rod is corroded to a depth of 0.1 inch all around, the cross section is reduced by 36 per cent.**

**2—For plate and sheet fabrication the material cost usually is a far greater part of the final cost than is the case for wire and rod products. For this reason if the best corrosion resisting material for any application is also the most costly, as may often be the case, the use of the best material is much better warranted for wire and rod applications than for plate.**

**3—Wire and rod products are usually installed at vital points and at points where corrosion, even though allowed for by additional size, will cause slackness or loss of proper rigidity which will render the parts useless before they actually fail by breakage. The most vital instance of this is in the case of springs, where a corrosion allowance cannot be made because of the fact that increasing the wire size would render the spring too stiff for proper action, and where any corrosion of the proper size wire will cause the spring to become too flexible. In the case of wire screen cloth, corrosion of the wire will enlarge the mesh and will thereby often cause the cloth to become unserviceable long before it would become weak enough to fail mechanically.**

✦ ✦ ✦

## Chemical Analyses and Physical Constants

TABLE I shows approximate chemical analyses of Monel, Nickel, and Inconel. It will be noted that wrought nickel is essentially a pure metal; that Monel is approximately 2/3 nickel and 1/3 copper; and that Inconel is an alloy containing approximately 80 per cent nickel, 13 per cent chromium, and 7 per cent iron. "R" Monel has the same basic analysis as Monel, with the addition of small amounts of sulfur to develop better machinability. "K" Monel and "Z" nickel have essentially the same analyses as Monel and nickel, respectively, with special additions to render them responsive to precipitation hardening.

CARL ROLLE

Born in Philadelphia, March 15, 1910, and attended high school in that city. Entered Pennsylvania State College in 1928 and in 1932 received the degree of B.S. in Mechanical Engineering. In 1933 received the degree of M.S. in Mechanical Engineering at M.I.T. and became engaged in marine engineering work with the United Fruit Co. Since 1936 has been following the fabrication of nickel and nickel base alloys with the Development and Research Division of the International Nickel Co., Inc. Member of The Wire Association.

✦ ✦ ✦

TABLE II shows average values of the important physical constants for these materials, and the following points are worthy of note:

**1—High melting points in all cases.**
**2—Thermal expansion coefficients very nearly the same as that of steel.**
**3—The high thermal conductivity of nickel.**
**4—High moduli of elasticity, yielding stiffnesses equal or nearly equal to that of steel and greatly superior to those of other non-ferrous materials.**
**5—The range of magnetic attraction possibilities. Nickel can be used in applications demanding strong magnetic properties, Monel is magnetic to only a slight degree at room temperature, Inconel is magnetic only at very low temperatures, and "K" Monel is non-magnetic even in heavily cold-worked form and at very low temperatures.**

✦ ✦ ✦

## Physical Properties

TABLES III to VIII, inclusive, show the ranges of physical properties of the various available wire and rod forms of Monel, "R" Monel, "K" Monel, nickel, "Z" nickel, and Inconel, respectively.

✦ ✦ ✦

ALL properties are given for room temperature. It is not-

TABLE I
APPROXIMATE CHEMICAL ANALYSES

| | Ni | Cu | Fe | Mn | Si | C | Cr |
|---|---|---|---|---|---|---|---|
| MONEL | 67. | 30. | 1.4 | 1.0 | 0.1 | 0.15 | .... |
| NICKEL | 99.4 | 0.1 | 0.15 | 0.2 | 0.05 | 0.10 | .... |
| INCONEL | 79.5 | 0.2 | 6.5 | 0.25 | 0.25 | 0.08 | 13. |

able that these materials not only possess a rarely found combination of strength and ductility, but that the strength is retained to a high degree at elevated temperatures while the toughness, as measured by the impact value, is retained at sub-zero temperatures. Table IX shows the results obtained by

TABLE II
PHYSICAL CONSTANTS

| | MONEL | "R" MONEL | "K" MONEL | NICKEL | "Z" NICKEL | INCONEL |
|---|---|---|---|---|---|---|
| Density, Lb/cu. in. | 0.318 | 0.318 | 0.310 | 0.319 | 0.316 | 0.309 |
| Specific Gravity | 8.80 | 8.80 | 8.60 | 8.85 | 8.75 | 8.55 |
| Melting Point, °F | 2460 | 2460 | 2400-2460 | 2640 | 2590 | 2540 |
| Specific Heat at 80-212 °F | 0.127 | 0.127 | 0.127 | 0.130 | 0.130 | 0.109 |
| Coeff. Linear Expansion at 80-212°F | .0000078 | .0000078 | .0000078 | .0000072 | .0000072 | .0000064 |
| Thermal Conductivity at—100 212°F, BTU/sq. ft., hr., °F, and in. | 180 | 180 | 180 | 420 | 420 | 105 |
| Modulus of Elasticity: Tension, Lb./sq. in. | 26 x $10^6$ | 26 x $10^6$ | 26 x $10^6$ | 30 x $10^6$ | 30 x $10^6$ | 31 x $10^6$ |
| Torsion, Lb/sq. in. | 9.5 x $10^6$ | 9.5 x $10^6$ | 9.5 x $10^6$ | 11 x $10^6$ | 11 x $10^6$ | 11 x $10^6$ |
| Magnetic Attraction at—100° F | weak | weak | none | decided | decided | weak |
| at 70°F | weak | weak | none | decided | decided | very weak |
| at 200°F | very weak | very weak | none | decided | decided | none |
| Electrical Resistivity at 32°F, Ohms/circ. mil ft. | 256 | | 373 | 63 | 95 | 575 |

TABLE III
PHYSICAL PROPERTIES OF MONEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | Yield Strength (0.01% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000Kg.) | Izod Impact Ft. Lb. |
|---|---|---|---|---|---|---|
| Cold Drawn Wire Annealed Temper | 70,000-85,000 | 30,000-40,000 | 20,000-30,000 | 50-35 | ..... | ..... |
| No. 1 Temper | 95,000-110,000 | ..... | ..... | 10-5 | ..... | ..... |
| Regular Temper | 110,000-140,000 | ..... | ..... | 8-4 | ..... | ..... |
| Spring Temper | 140,000-170,000 | ..... | ..... | 4-2 | ..... | ..... |
| Cold Drawn Rods Annealed Temper | 70,000-85,000 | 30,000-40,000 | 20,000-30,000 | 50-35 | 120-160 | 120+ |
| As Drawn Temper | 85,000-125,000 | 60,000-95,000 | 45,000-75,000 | 35-15 | 160-220 | 115-75 |
| Hot Rolled Rods As Rolled Temper | 80,000-95,000 | 40,000-65,000 | 25,000-40,000 | 45-30 | 130-170 | 120+ |
| Forged Rods As Forged Temper | 80,000-110,000 | 60,000-85,000 | 45,000-65,000 | 40-20 | 130-220 | 115-80 |

testing hot rolled rods at both high and low temperatures.

✦ ✦ ✦

THIS combination of properties not only renders the high nickel materials extremely useful where both strength and ductility are necessary, along with corrosion resistance, but also causes them to be particularly useful where exposed to temperatures above or below the normally experienced range of, say, 0° F. to 400° F. Frequently, therefore, they are employed in applications where their excellent corrosion resisting properties are not demanded, but where their physical characteristics alone enable them to gain preference over other materials.

✦ ✦ ✦

## Forms

THE properties given in the tables are for the following mill forms which are of interest to the wire and rod product industries:

**1—Cold Drawn Wire, annealed and spring tempers.**
**2—Cold Drawn Rods, annealed and "as drawn" tempers.**
**3—Hot Rolled Rods.**
**4—Forged Rods.**
**5—In the case of "K" Monel and "Z" nickel, data are given for heat treated material of each form as well.**

WIRE can be drawn, of course, to tempers intermediate between the annealed and spring tempers, and it is usually produced to tensile strength specifications. It is found that for any given production operation requiring cold working of the metal, the best results will be obtained from wire within a given range of tensile strength. The material can be produced to best suit any particular job.

✦ ✦ ✦

MONEL and nickel wire are produced regularly in two intermediate tempers, "No. 1" and "Regular." The former is used ex-

TABLE IV
PHYSICAL PROPERTIES OF "R" MONEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000Kg) |
|---|---|---|---|---|
| Cold Drawn Wire<br>As Drawn Temper | 100,000-115,000 | 75,000-95,000 | 10-5 | 180-240 |
| Cold Drawn Rods<br>As Drawn Temper | 80,000-100,000 | 60,000-90,000 | 35-15 | 140-220 |
| Hot Rolled Rods<br>As Rolled Temper | 75,000-95,000 | 35,000-65,000 | 45-30 | 130-165 |

TABLE V
PHYSICAL PROPERTIES OF "K" MONEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | Yield Strength (0.01% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000Kg) | Izod Impact Ft. Lb. |
|---|---|---|---|---|---|---|
| Cold Drawn Wire<br>Annealed Temper | 90,000-110,000 | 50,000-70,000 | 30,000-50,000 | 50-45 | ..... | ..... |
| Annealed Temper-Heat Treated | 130,000-150,000 | 90,000-110,000 | 75,000-90,000 | 30-20 | ..... | ..... |
| Spring Temper | 135,000-165,000 | ..... | ..... | 4-2 | ..... | ..... |
| Spring Temper-Heat Treated | 165,000-200,000 | ..... | ..... | 8-3 | ..... | ..... |
| Cold Drawn Rods<br>Annealed Temper | 90,000-110,000 | 50,000-70,000 | 30,000-50,000 | 50-45 | 120-180 | 120-100 |
| Annealed Temper-Heat Treated | 130,000-150,000 | 90,000-110,000 | 75,000-90,000 | 30-20 | 220-260 | 80-40 |
| As Drawn Temper | 110,000-135,000 | 70,000-95,000 | 50,000-75,000 | 45-35 | 175-250 | 100-80 |
| As Drawn Temper-Heat Treated | 140,000-165,000 | 100,000-125,000 | 80,000-105,000 | 30-15 | 260-320 | 40-20 |
| Hot Rolled Rods<br>As Rolled Temper | 90,000-110,000 | 50,000-70,000 | 30,000-50,000 | 50-45 | 120-180 | 120-100 |
| As Rolled Temper-Heat Treated | 135,000-155,000 | 95,000-115,000 | 80,000-95,000 | 30-20 | 260-300 | 80-40 |
| Forged Rods<br>As Forged Temper | 90,000-115,000 | 50,000-75,000 | 30,000-55,000 | 50-40 | 120-200 | 120-100 |
| As Forged Temper-Heat Treated | 135,000-160,000 | 95,000-120,000 | 80,000-100,000 | 30-20 | 260-310 | 80-35 |

tensively for cold heading work in sizes under 3/8 inch, and the latter for cold forming work in such applications as do not demand the use of a full spring temper.

✦ ✦ ✦

## Variation of Properties With Size

THE term wire, as used in connection with these materials, applies to round or special sections under ½ inch. Cold drawn rods are produced up to 3 inch, hot rolled rods up to 4 inch, and forged rods over 4 inch sizes. In all cases, the minimum strength and the maximum ductility of the ranges given will apply to material of the largest size coming within that category, while the smaller sizes will have properties nearest the maximum strength and minimum ductility of the given ranges.

✦ ✦ ✦

THE reason for this, of course, is that in the case of cold drawn material the smaller sizes can be given a greater degree of cold reduction; and in the case of hot rolled or forged material the smaller sizes will finish at lower temperatures and will therefore be given the equivalent of some degree of cold work. For this last reason, forgings can be produced to better properties than hot rolled rods of the same size. The work will be finished at a lower temperature and some light forging can be done below the annealing temperature.

✦ ✦ ✦

## Corrosion Resistance

THESE materials exhibit their highest degree of resistance to

TABLE VI
PHYSICAL PROPERTIES OF NICKEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb. sq. in. | Yield Strength (0.2% set) Lb/sq. in. | Yield Strength (0.01% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000 Kg.) | Izod Impact Ft. Lb. |
|---|---|---|---|---|---|---|
| Cold Drawn Wire Annealed Temper | 65,000-85,000 | 20,000-30,000 | 15,000-25,000 | 50-30 | ..... | ..... |
| No. 1 Temper | 90,000-105,000 | ..... | ..... | 10-5 | ..... | ..... |
| Regular Temper | 105,000-135,000 | ..... | ..... | 8-4 | ..... | ..... |
| Spring Temper | 135,000-160,000 | ..... | ..... | 4-2 | ..... | ..... |
| Cold Drawn Rods Annealed | 65,000-85,000 | 20,000-30,000 | 15,000-25,000 | 50-30 | 100-140 | 110 |
| As Drawn Temper | 80,000-115,000 | 60,000-90,000 | 40,000-70,000 | 35-15 | 140-200 | 100-60 |
| Hot Rolled Rods As Rolled Temper | 70,000-85,000 | 20,000-30,000 | 15,000-25,000 | 45-35 | 110-150 | 100 |
| Forged Rods As Forged Temper | 75,000-105,000 | 50,000-80,000 | 35,000-55,000 | 40-20 | 110-180 | 100-60 |

TABLE VII
PHYSICAL PROPERTIES OF "Z" NICKEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | Yield Strength (0.01% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000 Kg.) |
|---|---|---|---|---|---|
| Cold Drawn Wire Annealed Temper | 90,000-120,000 | ..... | ..... | 40-25 | ..... |
| Annealed Temper-Heat Treated | 160,900-180,000 | ..... | ..... | 15-7 | ..... |
| Spring Temper | 160,000-200,000 | ..... | ..... | 5-2 | ..... |
| Spring Temper-Heat Treated | 200,000-240,000 | ..... | ..... | 10-5 | ..... |
| Cold Drawn Rods As Drawn Temper | 90,000-150,000 | 50,000-130,000 | ..... | 35-15 | 150-300 |
| As Drawn Temper-Heat Treated | 160,000-190,000 | 120,000-150,000 | 100,000-130,000 | 20-7 | 300-380 |
| Hot Rolled Rods As Rolled Temper | 90,000-120,000 | 35,000-65,000 | ..... | 40-25 | 150-225 |
| As Rolled Temper-Heat Treated | 160,000-180,000 | 120,000-140,000 | 100,000-120,000 | 20-10 | 300-350 |

TABLE VIII

PHYSICAL PROPERTIES OF INCONEL WIRE AND RODS

| FORM OF MATERIAL | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | Yield Strength (0.01% set) Lb/sq. in. | % Elongation in 2 in. | Brinell Hardness (3000 Kg.) | Izod Impact Ft. Lb. |
|---|---|---|---|---|---|---|
| Cold Drawn Wire Annealed Temper | 80,000-95,000 | 30,000-40,000 | 20,000-30,000 | 55-45 | ..... | ..... |
| Spring Temper | 175,000-200,000 | ..... | ..... | 4-2 | ..... | ..... |
| Cold Drawn Rods Annealed Temper | 80,000-95,000 | 30,000-40,000 | 20,000-30,000 | 55-45 | 110-150 | 120+ |
| As Drawn Temper | 100,000-130,000 | 80,000-105,000 | 45,000-80,000 | 30-20 | 160-250 | 100-70 |
| Hot Rolled Rods As Rolled Temper | 95,000-115,000 | 40,000-80,000 | 20,000-50,000 | 50-25 | 140-200 | 120-100 |
| Forged Rods As Forged Temper | 95,000-120,000 | 60,000-90,000 | 50,000-70,000 | 45-25 | 180-240 | 120-100 |

TABLE IX

RESULTS OF SHORT TIME TENSILE TESTS AND IMPACT TESTS ON HOT ROLLED RODS AT VARIOUS TEMPERATURES

| MATERIAL | Test Temp. °F | Tensile Strength Lb/sq. in. | Yield Strength (0.2% set) Lb/sq. in. | % Elongation in 2 in. | Izod Impact Ft. Lb. |
|---|---|---|---|---|---|
| MONEL | -423 | 142,000 | 96,300 | 38.5 | ..... |
| | -297 | 128,250 | 91,500 | 40 | 119 |
| | 70 | 90,000 | 67,000 | 31 | 119 |
| MONEL | 70 | 85,000 | 45,000 | 45 | ..... |
| | 600 | 80,000 | 34,000 | 44 | ..... |
| | 800 | 70,000 | 30,000 | 40 | ..... |
| | 1000 | 55,000 | 27,000 | 30 | ..... |
| | 1200 | 36,000 | 23,000 | 18 | ..... |
| "K" MONEL | 75 | 97,000 | 42,500 | 49.0 | ..... |
| | 200 | 95,000 | 42,000 | 50.0 | ..... |
| | 400 | 94,000 | 40,000 | 53.0 | ..... |
| | 600 | 90,500 | 37,000 | 56.5 | ..... |
| | 800 | 83,500 | 37,500 | 53.5 | ..... |
| | 1000 | 75,500 | 33,500 | 31.5 | ..... |
| NICKEL | -292 | 98,000 | ..... | ..... | 98 |
| | -112 | 76,500 | ..... | ..... | 92 |
| | 70 | 65,600 | ..... | ..... | 89 |
| NICKEL | 70 | 81,000 | 25,000 | 54 | ..... |
| | 212 | 82,000 | 24,000 | 54 | ..... |
| | 392 | 83,000 | 23,000 | 54 | ..... |
| | 572 | 83,000 | 22,000 | 54 | ..... |
| | 842 | 78,000 | 20,500 | 54 | ..... |
| | 932 | 64,000 | 20,000 | 54 | ..... |
| | 1112 | 49,000 | 19,500 | 52 | ..... |
| | 1292 | 36,000 | 15,000 | 43 | ..... |
| INCONEL | -315 | 117,000 | ..... | 51 | 169* |
| | 70 | 90,000 | 36,000 | 50 | 213* |
| INCONEL | 70 | 90,000 | 36,000 | 50 | ..... |
| | 600 | 88,000 | 35,000 | 50 | ..... |
| | 800 | 84,000 | 33,000 | 49 | ..... |
| | 1000 | 72,000 | 29,000 | 44 | ..... |
| | 1200 | 59,000 | 25,000 | 27 | ..... |
| | 1400 | 45,000 | 20,000 | 25 | ..... |
| | 1600 | 32,000 | 15,000 | 30 | ..... |
| | 1800 | 18,000 | 10,000 | 41 | ..... |
| | 2000 | 8,000 | 5,000 | 65 | ..... |

*Charpy Impact, Ft. Lb.

acid corrosion under reducing conditions, and tend to have their corrosion accelerated by oxidizing acids and compounds.

✦ ✦ ✦

MONEL is most versatile in its corrosion resistance since it resists the attack of mineral and organic acids, alkalies, and salts over a wide range of concentrations and exposure conditions. The special types of Monel have the same corrosion resisting characteristics as regular Monel.

✦ ✦ ✦

NICKEL is similar to Monel in its corrosion resistance. It is generally inferior in resistance to acids, about the same in resistance to salts, and a little better in resisting alkalies. The corrosion resisting characteristics of "Z" nickel are the same as those of regular nickel.

✦ ✦ ✦

INCONEL was developed primarily to resist corrosion and tarnishing by foods, and this it does to an admirable degree. It is also superior to Monel and nickel in resisting strongly oxidizing acid solutions and dilute organic acids.

✦ ✦ ✦

THE following results are based on a large number of both laboratory and field corrosion tests, supplemented by practical experience. Where corrosion rates are cited, they will be referred to in terms of inches penetration per year, abbreviated "ipy", which means the depth to which uniform corrosion would penetrate during continuous exposure for one year.

✦ ✦ ✦

### Atmospheric Corrosion

CORROSION of Monel, nickel, or Inconel is practically nil, even in sulfurous industrial atmospheres, being less than 0.0001 ipy in outside exposure. In indoor exposure all remain substantially unchanged, that is, free from such effects as the rusting of steel. Inconel is somewhat superior to Monel and nickel, since it is relatively free from the "fogging" that sometimes occurs with Monel and nickel if they are left for long periods in damp, sulfurous atmospheres without cleaning. In outdoor exposure, Monel and nickel will remain bright only in rural atmospheres that are essentially free from sulfur gases. In other atmospheres, they will acquire brownish or greenish tarnish films at a rate that depends on the humidity and the sulfur content of the atmosphere.

✦ ✦ ✦

INCONEL is not completely immune to tarnishing in sulfurous atmospheres, but compares favorably with the best of other alloys that are considered to possess satisfactory resistance to tarnishing outdoors. In clean country air Inconel will remain bright indefinitely. Free exposure to the atmosphere is more favorable than partially sheltered exposure.

✦ ✦ ✦

### Fresh Water

ALL three materials are highly resistant to corrosion by distilled water and by hard and soft natural waters. Rates of corrosion are usually less than 0.00001 ipy and rarely more than 0.001 ipy, even under the most severe conditions of temperature, flow, and aeration. The order of merit is Inconel, nickel, and Monel; with the practical advantage of the first two being principally in connection with waters high in salts and containing appreciable amounts of free carbon dioxide.

✦ ✦ ✦

### Salt Water

WHILE all three materials are highly resistant to sea water corrosion, Monel is usually the best choice for reasons of economy. Monel finds its greatest usefulness under conditions of contact with salt water at high velocity, where its resistance to the effect of impingement and cavitation is important. Conditions of stagnant exposure are less favorable, since the accumulation of marine organisms and other solids may induce pitting. None of these materials is non-fouling, since their corrosion products are not toxic to marine organisms. Resistance to pitting is in the order of Monel, nickel, and Inconel. Resistance to marine atmospheres is in the order of Inconel, nickel and Monel.

### Neutral and Alkaline Salts

SUCH salt solutions, including chlorides, carbonates, sulfates, nitrates, acetates, etc., have a negligible corrosion effect on all three materials. Rates of corrosion, even in hot, aerated solutions, are usually less than 0.001 ipy, and rarely more than 0.005 ipy.

✦ ✦ ✦

### Acid Salts

MONEL is generally superior to nickel and Inconel in resisting corrosion by acid salts, such as zinc and ammonium chlorides, ammonium and aluminum sulfates, etc. Rates of corrosion of all three are usually less than 0.02 ipy.

✦ ✦ ✦

### Oxidizing Acid Salts

NEITHER Monel nor nickel is very resistant to more than dilute solutions of most oxidizing acid salts, such as ferric chloride, ferric sulfate, cupric chloride, mercuric chloride, silver nitrate, etc. Nickel is superior to most other materials, however, in resisting stannic chloride at atmospheric temperatures.

✦ ✦ ✦

INCONEL is resistant to many oxidizing acid salt solutions, such as silver nitrate, chromates, dichromates, permanganates, nitrates, nitrites, copper sulfate, etc. It does not resist such salts as ferric chloride, cupric chloride, or mercuric chloride, except in very dilute solutions.

✦ ✦ ✦

### Oxidizing Alkaline Salts

HYPOCHLORITES are the only common alkaline salts that are corrosive to these materials. The limiting concentration of available chlorine that can be handled safely is 3 grams per litre. With this concentration contact should not be continuous, and the hypochlorite solution should be followed by rinsing and souring (acid) solutions as in cyclic bleaching operations. These materials are quite resistant to alkaline peroxide solutions and have practically no catalytic effect on their decomposition.

### Sulfuric Acid

MONEL is the best of the three as far as general resistance to sulfuric acid is concerned. In air-free acid at atmospheric temperature, the corrosion of Monel is practically nil in all concentrations up to 80 per cent. In air-saturated acid below 80 per cent concentration, the maximum rate of corrosion of about 0.04 ipy occurs in 5 per cent acid. Above 80 per cent, rates increase rapidly, and above 87 per cent are even higher than at 5 per cent. However, in the presence of oils, etc., Monel resists concentrations over 80 per cent, as in sulfonation processes and the handling of acid sludges in oil refineries.

✦ ✦ ✦

IN air-free acid, the effect of temperature on the corrosion of Monel is negligible. In air-saturated acid, the greatest activity occurs at a temperature of about 185° F. For example, the corrosion of Monel in 5 per cent acid at 185° F. is at a rate of about 3 times that at atmospheric temperature. The highly reducing conditions of steel pickling solutions favor Monel; and, in galvanic contact with steel, the corrosion of Monel pickling equipment is negligible. Monel may be used successfully in boiling sulfuric acid in concentrations up to 20 per cent by weight.

✦ ✦ ✦

NICKEL is generally inferior to Monel in sulfuric acid solutions. The difference is not great at atmospheric temperature, but at considerably higher temperatures caution should be exercised in the use of nickel in acid stronger than about 25 per cent. Even in concentrations below this, rates of 0.1 ipy may be experienced.

✦ ✦ ✦

INCONEL possesses fair resistance to sulfuric acid. In most concentrations it is inferior to Monel or nickel, but it is practically free from corrosion by the very dilute solutions used in the textile dyeing industry.

✦ ✦ ✦

### Hydrochloric Acid

MONEL and nickel are among the few strong, wrought materials possessing useful resistance to corrosion by hydrochloric acid. At atmospheric temperature, nickel is slightly superior to Monel in air-saturated acid under 10 per cent concentration, and is slightly inferior in air-saturated acid of greater than 10 per cent concentration or in air-free acid of any concentration. The rates of corrosion increase uniformly with the acid concentration from about 0.03 ipy in 1 per cent to 0.25 ipy in 30 per cent, air-saturated acid, and from about 0.01 ipy in 1 per cent to 0.05 ipy in 30 per cent acid free from dissolved air or other oxidizing impurities.

✦ ✦ ✦

AT elevated temperatures, corrosion increases rapidly. As a general rule, the use of Monel and nickel in hydrochloric acid at temperatures over 120° F. is confined to concentrations under 2 per cent. Typical applications include equipment for steel pickling, fruit washing, glass washing, etc.

✦ ✦ ✦

NICKEL is used extensively for chlorinating equipment, as in the chlorination of paraffin. Nickel and Monel are highly resistant to chlorinated hydrocarbons such as are used in dry cleaning equipment and in solvent extraction processes.

✦ ✦ ✦

INCONEL possesses fair resistance to hydrochloric acid: tests in air saturated 5 per cent acid showed a rate of corrosion of 0.12 ipy. It has demonstrated excellent resistance to cold, aerated acid under 2 per cent, but should be used with caution in hot acid solutions.

✦ ✦ ✦

### Other Mineral Acids

MONEL, nickel, and Inconel are resistant to hydrofluoric acid and to mixtures of hydrofluoric acid and ammonium bifluoride used for glass etching. Tests in 6 per cent acid used for pickling cast iron showed a rate of corrosion of Monel of 0.0008 ipy. Rates are higher at higher temperatures and in stronger concentrations.

✦ ✦ ✦

MONEL, nickel, and Inconel all possess useful resistance to corrosion by solutions containing hydrogen sulfide, Inconel being superior to the others.

✦ ✦ ✦

ALTHOUGH Monel, nickel, and Inconel should be used with caution in solutions containing sulfurous acid in appreciable concentrations, dilute solutions, such as are used in the preservation of fruits, may be handled successfully. Inconel is superior from the standpoint of resistance to tarnishing.

✦ ✦ ✦

### Organic Acids and Compounds

MONEL, nickel, and Inconel are highly resistant to corrosion by all the common organic acids. Inconel is generally most resistant to dilute acids (under 10 per cent) and Monel to more concentrated acids. Inconel is especially resistant to fatty acids at elevated temperatures.

✦ ✦ ✦

ALL three materials are useful in connection with the handling of acid foods. This is due not only to excellent corrosion resistance, but also to the facts that nickel is non-destructive to vitamins and is non-toxic.

✦ ✦ ✦

### Alkalies

NICKEL, Monel, and Inconel are outstanding in their practically complete resistance to corrosion by alkaline solutions. Nickel is preferred where the product must be kept free from copper and iron, and for contact with highly concentrated solutions at elevated temperatures. Inconel is best for alkaline sulfide solutions, such as hot concentrated sodium sulfide.

✦ ✦ ✦

IN the absence of sulfur, nickel forms a protective oxide when in contact with fused caustic and is second only to silver in resistance to it. Nickel for this purpose should be fully annealed before exposure. When sulfur is present, as in "shading" operations, nickel should not be used.

✦ ✦ ✦

INCONEL is resistant to anhydrous ammonia and ammonium hydroxide solutions under a wide variety of conditions. Nickel and Monel are highly resistant to an-

hydrous ammonia as used for refrigeration. In aqua ammonia Monel does not corrode in solutions containing up to 3 per cent ammonia. The limiting concentration for nickel is about 1 per cent.

✦ ✦ ✦

## Wet and Dry Gases

MONEL, nickel, and Inconel are unaffected by all common gases at atmospheric temperature, so long as they are dry. In the presence of appreciable moisture, all are subject to corrosion by chlorine, bromine, and sulfur dioxide. Monel and nickel are corroded by wet ammonia and nitric oxide, though Inconel is resistant.

✦ ✦ ✦

MONEL containing less than 0.5 per cent manganese, nickel, and Inconel are useful in contact with cracking ammonia in nitriding operations; Inconel being superior to the other two. None of these materials is useful against mixtures of hydrogen and nitrogen under conditions appropriate to ammonia synthesis.

✦ ✦ ✦

IN reducing sulfur atmospheres; the upper useful temperature limit for Monel and nickel is about 700° F., and for Inconel about 1000° F. In oxidizing sulfur atmospheres; the limiting temperatures are 1000° F. for Monel and nickel, and 1500° F. for Inconel. In sulfur-free oxidizing atmospheres; the limiting temperatures are 1000° F. for Monel, 1400° F. for nickel and 2000° F for Inconel. Nickel possesses a peculiar usefulness at temperatures from 2100° F. to 2300° F.

✦ ✦ ✦

IN steam; Monel is unaffected below 700° F. to 800° F., and nickel below 800° F. The upper useful limit for Inconel in steam has not been established, but it is above 1000° F.

✦ ✦ ✦

## Hot Working

THESE materials; with the exception of "R" Monel, which is not recommended for hot working operations; are capable of being forged into any shapes regularly produced in steel, although their high strengths at forging temperatures require somewhat increased power. This is particularly true in the case of single blow or press forging work, such as is commonly used in the hot upsetting of bolt or rivet heads.

✦ ✦ ✦

THE successful hot working of Monel, nickel, and Inconel depends largely upon the heating conditions. The points to be observed carefully are as follows:

**1—Heating temperature.**
**2—Heating time.**
**3—Fuels, furnaces and atmospheres used.**

✦ ✦ ✦

## Heating Temperature and Time

FIGURE 1 shows the recommended working temperature ranges. These limits should be adhered to as closely as possible. The ranges marked "no forging" and "no bending" should be strictly avoided in order to totally escape cracking or edge checking.

✦ ✦ ✦

THE length of heating time is also very important, and the work should be arranged so that material is charged into the furnace at regular intervals and will have only sufficient time to be heated throughout to the desired temperature before it is withdrawn for working. If operations are stopped for any reason at all, material should be withdrawn from the furnace, to be recharged when work is resumed. Under no conditions should these materials be

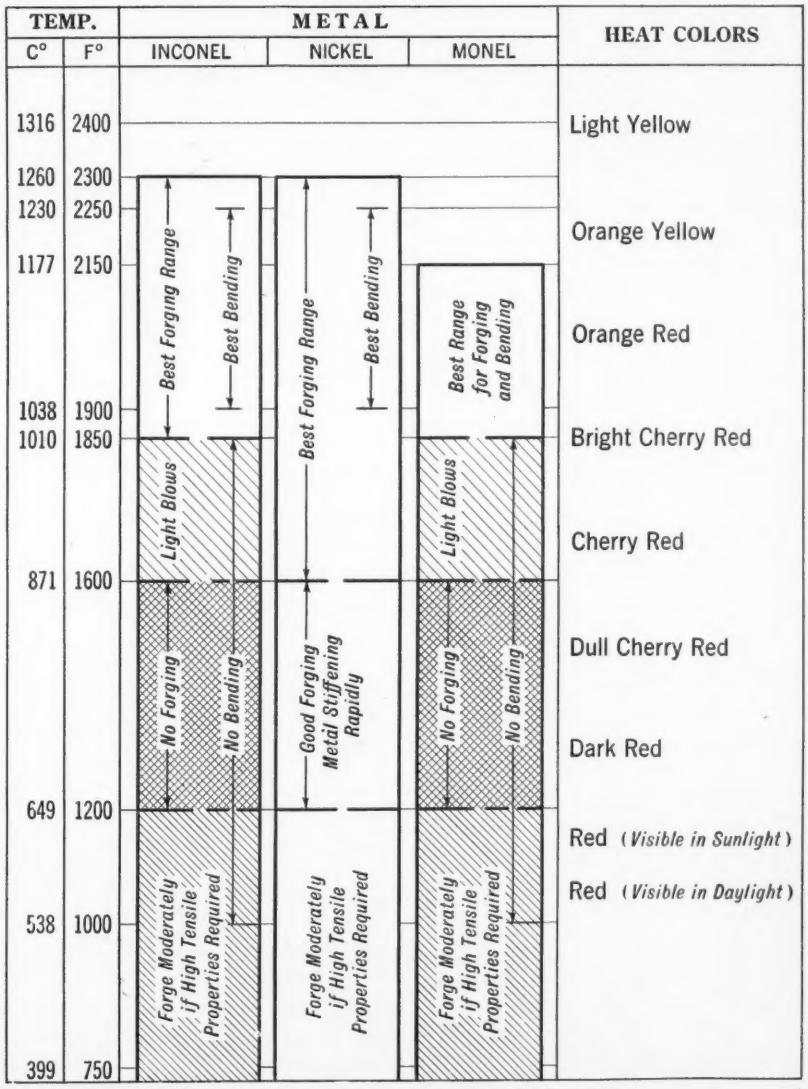



**Fig. 1. Recommended temperature ranges for hot working of nickel base alloys.** ✦ ✦

allowed to "soak" in the furnace, particularly if several reheatings are required in the course of the work, because "soaking" is definitely harmful.

✦ ✦ ✦

TABLE X shows the approximate length of time required to heat various sizes of round or square rods to forging temperatures. Short slugs will require 30 to 50 per cent less time; wide flats will require 50 to 100 per cent greater time than indicated by the table for a given thickness.

✦ ✦ ✦

## Fuels and Furnaces

THE chief points to consider in the selection of fuels and furnaces are the use of low sulfur fuels, the avoidance of having combustion take place in direct contact with the material, and the avoidance of highly oxidizing atmospheres.

✦ ✦ ✦

THE fuel should contain not more than 0.5 per cent sulfur and preferably not more than 0.2 per cent. Oil is the fuel most commonly used for forge heating; and if the sulfur content is sufficiently low, and the furnace is so designed that combustion takes place before the hot gases come in contact with the material, this makes a very satisfactory fuel. Gas-fired furnaces are even more suitable, since combustion takes place more rapidly. Sulfur-free natural gas is used exclusively as a fuel in connection with the production of Monel, nickel, and Inconel mill forms.

✦ ✦ ✦

CITY gas, butane and propane also make very satisfactory fuels. Producer gas, if washed, is an acceptable fuel, but unwashed gas should not be used. Coal and coke are, in general, unsatisfactory; both because of the usually appreciable sulfur content and the fact that combustion takes place in direct contact with the material. However, the low sulfur grades may serve when nothing better is available, but it is necessary to watch the heating very carefully.

TABLE X
RANGE OF TIME REQUIRED
TO HEAT TO FORGING TEMPERATURE

| SIZE OF ROUND OR SQUARE | TOTAL TIME IN FURNACE—MINUTES | | |
|---|---|---|---|
| | MONEL | NICKEL | INCONEL |
| ½ inch | 2-5 | 3-7 | 4-10 |
| 1 inch | 6-10 | 9-16 | 12-20 |
| 2 inches | 16-23 | 23-35 | 34-45 |
| 3 inches | 30-40 | 45-60 | 60-80 |
| 4 inches | 45-60 | 70-90 | 90-120 |
| 6 inches | 75-100 | 110-140 | 150-200 |

IT is advisable to control carefully the amount of air supplied for combustion of the fuel so that a neutral or reducing atmosphere will be maintained. This is most easily accomplished with gas or low distillate oils; these fuels, therefore, usually yield the most satisfactory results.

✦ ✦ ✦

FURNACES should be so designed as to provide ample space for combustion of the fuel before the hot gases reach the material, means of keeping the charge clear of the furnace floor, ample circulation of the products of combustion so as to maintain uniform temperatures throughout, and reasonable air-tightness so as to assist in maintaining the desired atmosphere.

✦ ✦ ✦

## Testing Furnace Conditions

THE following tests are recommended strongly in cases where the forgeman is unfamiliar with the working of these materials, or where the furnaces have never before been used for such work. To check for proper furnace conditions; heat a bar of about ½ inch round or ½ inch by 1 inch flat stock and hold at the desired temperature for 10 to 15 minutes, then withdraw and quench in water. The piece should then be bent cold through 180°, flat on itself, and if the heating conditions are correct, there will be no cracking or edge checking.

✦ ✦ ✦

TO check the heating temperature when no pyrometer is available, or where the forgeman is not experienced in estimating the temperatures of these materials from the heat colors; take several test pieces of about ½ in. by 1 inch by 6 to 8 inches long, bend slightly at the center, and then heat to the upper limit of the forging temperature range, using the heat color scale of Figure 1 for estimating purposes. One piece should be withdrawn and immediately bent flat on itself with a single upset thrust from a power hammer or press. Other pieces may be allowed to cool to varying temperatures before bending, and as long as no cracking occurs, the temperature is known to be safe for forging.

✦ ✦ ✦

ANOTHER good test of forging temperature is to take a 1 inch cube of material, heat it to the desired temperature, and flatten it under a power hammer to ⅛ inch thickness, using a few heavy blows. No cracking should result if the temperature is within the safe range.

✦ ✦ ✦

IN order to develop the best physical properties in hot worked products; forging should be stopped when the piece is nearly to the desired size and shape, the material should be allowed to cool to 1200° F. (barely visible red color), and the work then finished by semi-cold work below this temperature.

✦ ✦ ✦

## Cold Working

MONEL, nickel, and Inconel are essentially of the "work-hardening" type; that is, the hardness and strength increase as the material is cold worked, and to a higher degree than is found in some other metals. Figure 2 shows the relative rates of work-hardening of these and of other commonly used metals; Shore hardness being plotted against per cent reduc-

tion of cross-section by cold work. From this it will be seen that these materials cannot be worked as much as copper or aluminum before requiring annealing; but high ductility, even in the heavily cold worked condition, allows them to be worked severely without fracture, even though the work will require greater power than would be the case for softer materials. "Z" nickel is not shown on this chart, but its rate of work-hardening is very nearly the same as that of "K" Monel.

✦ ✦ ✦

## Selection of Material

IN sizes up to ⅝ inch, and frequently up to 1 inch, bolts are commonly made with cold upset heads and rolled threads. Annealed material is, of course, the type most easily applied to such work; although in Monel and nickel, No. 1 temper wire is suitable for this work in sizes ⅜ inch and under. Inconel and the heat treatable alloys, because of their higher rates of work-hardening, should be used in the annealed temper only; and it will be found difficult to cold-head sizes over ⅝ inch in the harder alloys. Of course, the final strength of the finished products must be considered when selecting the temper of material to be used, and it is for this reason that the harder temper should be used whenever the size and the nature of the operations permit.

✦ ✦ ✦

RIVETS of all sizes should be cold-headed from annealed material; not especially for reasons of production, for the operations are not more difficult than the cold-heading of bolts; but because the finished rivets should be annealed in any case so as to permit cold driving of the smaller sizes by the user. Cold-driving is commonly employed in sizes up to ⅜ inch for Monel and nickel, and in larger sizes soft material should be used in any case, as in bolt heading.

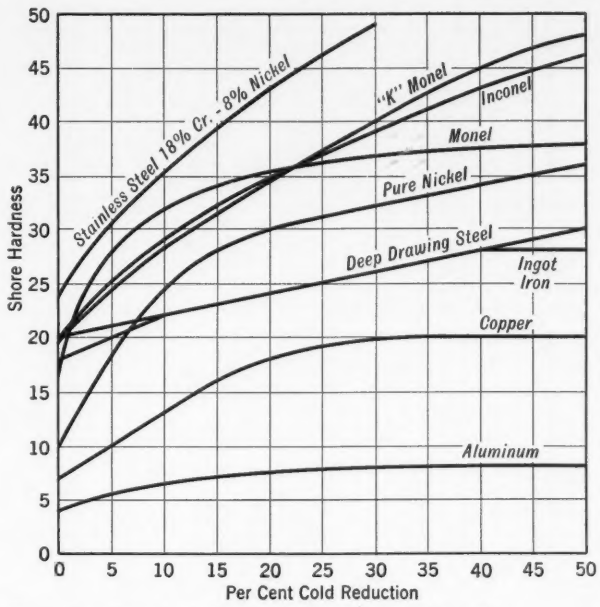



Fig. 2. Increase in hardness of various metals with cold working.

SPRING temper wire of any of these materials is capable of being bent around its own diameter, and the manufacture of springs or wire forms from this temper is perfectly practicable. In the production of small or moderate size coil springs, where automatic coilers are used, it is desirable to use high-speed steel or tungsten carbide tools wherever possible, so as to avoid galling of the wire which often will occur against plain carbon steel tools. In the coiling of small diameter wires it is often possible to use hard bronze guides and fingers with excellent success, although such tools, of course, will not yield as good life as would tungsten carbide or high-speed steel.

✦ ✦ ✦

THE production of cold bent products from rods offers no difficulties, due to the high ductility of these materials. In general, any bends that can be made safely with annealed or hot rolled steel rods can be accomplished easily with Monel, nickel, or Inconel, although it will be found that the higher yield strengths of these materials cause them to require somewhat greater power for bending.

✦ ✦ ✦

"R" MONEL is produced especially for free machining. It should be used with caution for parts requiring severe cold bending, because of its lower ductility. It is, however, perfectly safe for such products as "U" bolts, where the diameter of the bend is several times the rod diameter. On such items the machining advantages of "R" Monel will usually not reduce the total production cost; and the use of this alloy should be restricted to products in which the bending or forming is more or less incidental, and where machining constitutes the major portion of the work.

✦ ✦ ✦

IN work requiring very severe cold deformation, "K" Monel or "Z" nickel find a particular field of usefulness because of their ability to be heat treated. Soft "K" Monel and "Z" nickel may be heat treated after all cold forming has been done, and will then have physical properties far in excess of those obtained by purely work-hardening materials.

✦ ✦ ✦

## Machining

MACHINABILITY is actually a function of the physical properties of a material, and for this reason it is only natural that the high strength and toughness of Monel, nickel, and Inconel should cause them to require machining practices other than those used for more brittle materials. There are, however, proper combinations of tooling, speeds, feeds, and lubricants which, if provided, will allow them to be machined quite readily.

✦ ✦ ✦

"R" MONEL is a variation of regular Monel in which some of the toughness has been eliminated by adjustment of the chemical analysis. It is, therefore, much more rapidly machined, and is particularly adapted to the manufacture of automatic screw machine products. As mentioned previously, this alloy should not be used for products requiring hot work-

ing, and it will be found best to use it only when machining is the major item of production and where its improved machinability will thereby result in manufacturing economies sufficient to more than overcome the disadvantage of a reduction of about 10 per cent from regular Monel in physical properties.

✦ ✦ ✦

FOR maximum machinability, material should be in the "as drawn" or "as rolled" condition, as these forms will be less ductile and tough than annealed material. Cold drawn rods will, of course, have a clean surface not found in hot rolled rods and will, furthermore, have closer tolerances. This makes it most advisable to use cold drawn rods, especially for automatic chucking and where it is desired to remove the minimum amount of material.

✦ ✦ ✦

## Tools

IT is most advisable to use high-speed steel tools. It is found that the tungsten high-speed steels of the 18-4-1 high tungsten, low vanadium type, 0.70 to 0.75 per cent carbon, yield the most satisfactory results. Some trade names for this type of steel are Rex AA, Red Cut Superior, Blue Chip, Clarite, Maximum, and Gold Star.

✦ ✦ ✦

THE grinding of tools for cutting these materials is quite important and the following principles should govern this work.

**1—Do not sacrifice necessary support for the cutting edge by making the clearance angles greater than needed.**

**2—Grind sufficient true rake on the tool face to keep chip pressure, chip abrasion, and resultant frictional heat to a minimum, and to provide for convenient chip disposal.**

**3—Leave as much material as possible at the nose of roughing tools.**

✦ ✦ ✦

LATHE turning tools should be ground with side clearance and horizontal front clearance angles of 6° to 8°, and front clearance angles of from 6° for heavy work to 15° for light finishing cuts. Side rake should range from 10° for heavy work to 25° for very light work, and back rake should be from 6° to 8°. This provides the necessary tool support for heavy cuts, and at the same time provides sharper cutting edges for smooth finishing cuts.

✦ ✦ ✦

THE principle of increasing back rake wherever possible to do so without weakening the tool extends also to the grinding of threading tools and dies, taps, and milling cutters.

✦ ✦ ✦

WHEN cutting "K" Monel, "Z" nickel, or Inconel it is necessary to make allowance for their greater hardness by keeping clearance angles to the minium so as to provide the necessary tool support. In heavy roughing it will be found advantageous to grind a land of 1/32 in. to 3/64 in. width at the cutting edge to provide additional support.

✦ ✦ ✦

IT is desirable to set cutting edges slightly above center, except of course with cutting-off tools, but tools ground with a land at the cutting edge must be set on center.

✦ ✦ ✦

TOOLS should be kept sharply ground at all times, because tool breakdown becomes increasingly rapid and the finish on the work increasingly less desirable as the tool wears. It will therefore be found more economical in the long run to stop work whenever necessary to retouch tools and cutters. They should preferably be honed after grinding.

✦ ✦ ✦

## Lubricants

THE cutting of the high nickel materials generates considerable frictional heat, and for this reason a copious supply of cutting fluid should be provided, preferably by pouring it directly on the cutting edge of the tool. The lubricant table indicates the recommended cutting fluids for various types of work:

**LUBRICANT TABLE**

| OPERATION | MONEL OR NICKEL | "K" MONEL, "Z" NICKEL OR INCONEL |
|---|---|---|
| Rough Turning | Dry, or water soluble oil | Dry, or sulfurized oil |
| Finish Turning | Water soluble oil | Sulfurized oil |
| Milling | Sulfurized oil | Sulfurized oil |
| Drilling, under 3/32 in. | Turpentine or gasoline | Turpentine or gasoline |
| Drilling, 3/32 to 1/4 in. | Lard oil | Sulfurized oil (cut) |
| Drilling, over 1/4 in. | Sulfurized oil | Sulfurized oil |
| Threading | Sulfurized oil | Sulfurized oil |
| Tapping | Sulfurized oil | Sulfurized oil |
| Reaming | Sulfurized oil | Sulfurized oil |
| Machine sawing | Sulfurized oil | Sulfurized oil |

✦ ✦ ✦

WHEN using "R" Monel for automatic screw machine work, heavy sulfurized oil should be used in all operations. This alloy has been particularly developed to enable higher speed work to be accomplished in Monel, and a copious supply of coolant is necessary.

✦ ✦ ✦

## Cutting Speeds and Feeds

TABLES XI - XIII inclusive give recommended speeds and feeds for various machining operations, including automatic screw machine work on "R" Monel. It will be noted that Monel and nickel may be run at higher speeds than the harder materials, and in any case, machining of "K" Monel or "Z" nickel should always be done before these materials are heat treated.

✦ ✦ ✦

IN turning and boring operations, the best combination is one of a heavy cut with light feed, rather than a light cut with heavy feed.

✦ ✦ ✦

LATHE thread cutting is best done at speeds of 25 feet per minute for Monel or nickel, and 15 feet per minute for the harder materials. The cut should vary with the depth to which the tool has worked into the thread. Heavier cuts may be used to start, but the cut must be gradually reduced as more of the tool comes in contact with the cut thread.

✦ ✦ ✦

TAP drill sizes for these materials should be a little larger than for steel or brass, since the greater ductility will permit the material to flow into the root of

TABLE XI
RECOMMENDED SPEEDS, CUTS AND FEEDS FOR LATHE TURNING

| CUT INCHES | FEED INCHES | CUTTING SPEED. FEET PER MINUTE | | |
|---|---|---|---|---|
| | | MONEL NICKEL | "Z" NICKEL | INCONEL "K" MONEL |
| | .008 | 168 | 140 | 115 |
| 1/32 | 1/64 | 139 | 110 | 85 |
| | 1/32 | 118 | 95 | 75 |
| | 1/64 | 121 | 95 | 75 |
| 1/16 | 1/32 | 104 | 85 | 65 |
| | 1/16 | 60 | 50 | 40 |
| | 1/64 | 110 | 90 | 70 |
| 1/8 | 1/32 | 68 | 55 | 45 |
| | 1/16 | 48 | 40 | 35 |
| | 1/8 | 34 | 30 | 25 |
| | 1/32 | 57 | 47 | 37 |
| 1/4 | 1/16 | 39 | 33 | 27 |
| | 1/8 | 29 | 24 | 20 |
| | 1/32 | 52 | 40 | 30 |
| 3/8 | 1/16 | 34 | 30 | 25 |
| | 1/8 | 24 | 20 | 15 |
| | 1/32 | 49 | 40 | 32 |
| 1/2 | 1/16 | 31 | 25 | 20 |
| | 1/8 | 21 | 18 | 15 |

the tap thread and will result in the cutting of full depth threads with less power than if normal tap drill sizes are used and the threads formed entirely by cutting.

✦ ✦ ✦

THIS same point applies to die threading, in which case the rod can advantageously be cut to slightly undersize diameter before threading. Die heads should be of the self-opening type, because the use of solid dies will often cause a well cut thread to be spoiled in reversing and backing off the die.

✦ ✦ ✦

## Heat Treating

IN order to develop the maximum physical properties in "K" Monel and "Z" nickel, these alloys must be subjected to a precipitation hardening treatment at moderate temperatures. Inconel, and the other types of Monel and nickel do not respond to any such treatment.

✦ ✦ ✦

"K" MONEL must be held at the required temperature for the specified length of time and then cooled slowly to 800° F. before being removed from the furnace. The slow cooling is a very vital part of the treatment, and cooling rates of not more than 25° F. per hour, from the heat treating temperature down to 800° F., are the best. The rate of cooling from 800° F. to room temperature has no bearing on the results obtained from the heat treatment.

✦ ✦ ✦

SOFT "K" Monel, such as annealed, or hot worked and quenched material, is heat treated best by holding it at 1200°-1250° F. for one hour, followed by slow cooling to 800° F., and then by more rapid furnace cooling, air cooling or quenching.

✦ ✦ ✦

MODERATELY cold worked "K" Monel, such as cold drawn rod, is heat treated best at 1080°-1100° F. for 6 to 8 hours, followed by the slow cooling cycle to 800° F.

✦ ✦ ✦

HEAVILY cold worked "K" Monel, such as springs, is heat treated best at 980°-1000° F. for 6 to 8 hours, followed by slow cooling as before.

✦ ✦ ✦

"K" MONEL requires no preliminary conditioning to enable it to respond to heat treatment. Because of this fact, a full anneal cannot be accomplished except by quenching from about 1450° F. Were the material air cooled or furnace cooled after annealing, it would respond partially to heat treatment while passing through the 1000° F. to 1250° F. zone. This is of interest only in the complete softening of hot worked material, or in complete annealing between stages of cold work, and the quench has no bearing on the increase in hardness by the proper treatment.

✦ ✦ ✦

THE heat treatment of "Z" nickel differs from that of "K" Monel in two major respects. It must be quenched from 1950°-2000° F. during the final heating in order that it will respond to the precipitation hardening. Therefore, all hot worked "Z" nickel must be reheated and quenched after the hot work is completed. In annealing "Z" nickel, intermediate anneals are carried out at the same temperatures as used for regular nickel, but the last anneal must be carried out at 1950°-2000° F., followed by quenching.

✦ ✦ ✦

THIS accounts for the fact that "Z" nickel forgings, to be heat treated later, cannot be produced to increased properties by continuing the work down to about 1000° F.-1200° F., because the effects of any semi-cold work introduced into the material will be removed by the necessary high temperature quench anneal.

✦ ✦ ✦

THE other essential difference in heat treatment is that "Z" nickel does not require slow cooling after being held at the heat treating temperature. Following the holding period; the material may be rapidly furnace cooled, air cooled, or quenched.

✦ ✦ ✦

"Z" NICKEL is best heat treated by holding at 850°-900° F. for 8 to 16 hours; soft material being held nearer the 900° F. limit, and hard worked material being treated best at near the 850° F. limit. The hardening is progressive, but it will be found that for many purposes 8 to 12 hours at temperature will yield sufficient hardness, the remaining hours up to 16 yielding but a small further increase in hardness.

THE best results are obtained by heat treating these materials in electric furnaces with provision for maintaining a neutral or reducing atmosphere. Suggested atmospheres are cracked hydrocarbon gas with carbon dioxide and water vapor removed before admission to the furnace, cracked ammonia, nitrogen, or hydrogen.

✦ ✦ ✦

HYDROGEN atmospheres should not be used in connection with "Z" nickel, however, and at least 10 per cent hydrocarbons should be present in any furnace atmosphere in order to eliminate possible surface decarbonization. Decarbonization, if it occurs, will affect the hardness and strength of the surface material, and this may appreciably reduce the strength of thin sections.

✦ ✦ ✦

IN heat treating "K" Monel, it is possible to obtain a clean surface only by reducing the circulation of gases to practically nil. For this reason "K" Monel is best heat treated in a sealed muffle or pot placed in the furnace. Gas-fired furnaces with proper atmospheric control will yield satisfactory results, although it is more difficult to obtain a perfectly clean surface, particularly with "K" Monel.

✦ ✦ ✦

SURFACE oxidation, under good furnace conditions, will be extremely superficial and the oxide will be in the form of a tightly adherent film rather than a scale. This can be removed, if desired, by tumbling in sawdust and powdered emery, by a light buffing, or by

TABLE XII
RECOMMENDED SPEEDS AND FEEDS FOR DRILLING

| DRILL SIZE INCHES | MONEL & NICKEL | | Inconel & "Z" Nickel | | "K" MONEL | | "R" MONEL | |
|---|---|---|---|---|---|---|---|---|
| | R.P.M. | Feed/Rev. | R.P.M. | Feed/Rev. | R.P.M. | Feed/Rev. | R.P.M. | Feed/Rev. |
| 1/16 | 3050 | .0015 | 2450 | .0015 | 1525 | .0010 | 4000 | .002 |
| 3/32 | 2100 | .0020 | 1650 | .0020 | 1050 | .0015 | 2700 | .0025 |
| 1/8 | 1525 | .0025 | 1220 | .0025 | 765 | .0020 | 2000 | .003 |
| 3/16 | 1020 | .0030 | 815 | .0030 | 510 | .0025 | 1325 | .0035 |
| 1/4 | 920 | .0035 | 685 | .0035 | 460 | .0030 | 1150 | .004 |
| 5/16 | 735 | .0040 | 550 | .0040 | 370 | .0035 | 920 | .0045 |
| 3/8 | 610 | .0045 | 460 | .0045 | 305 | .0040 | 760 | .005 |
| 1/2 | 460 | .0055 | 345 | .0055 | 230 | .0050 | 575 | .006 |
| 5/8 | 365 | .007 | 275 | .007 | 185 | .006 | 460 | .008 |
| 3/4 | 305 | .009 | 230 | .009 | 155 | .007 | | |
| 7/8 | 175 | .011 | 130 | .011 | 90 | .008 | | |
| 1 | 150 | .013 | 115 | .013 | 75 | .009 | | |
| 1 1/4 | 120 | .015 | 90 | .015 | 60 | .010 | | |
| 1 1/2 | 100 | .015 | 75 | .015 | 54 | .010 | | |
| 1 3/4 | 85 | .016 | 65 | .016 | 43 | .011 | | |
| 2 | 75 | .016 | 57 | .016 | 38 | .012 | | |

TABLE XIII
RECOMMENDED FEEDS AND SPEEDS FOR AUTOMATIC SCREW MACHINING OF "R" MONEL

| OPERATION | WIDTH OF CUT IN INCHES | FEED IN INCHES | SPEED IN FEET PER MINUTE |
|---|---|---|---|
| Box Tool: | | | |
| Roughing | 1/32 | .006 | 100-125 |
| | 1/16 | .005 | 100-125 |
| | 1/8 | .004 | 100-125 |
| Finishing | .005 | .010 | 100-125 |
| Cut-off: | | | |
| Circular Tool / Straight Tool | 1/16 to 1/8 | .001 | 100-125 |
| Stock under 1/8 in. dia. | ..... | .0005 | 100-125 |
| Forming Tool: | | | |
| Circular | 1/8 to 1/4 | .0006 | 100-125 |
| | 3/8 to 1/2 | .0005 | 100-125 |
| | 5/8 to 3/4 | .0004 | 100-125 |
| | 1 | .00025 | 100-125 |
| Balance Turning Tool: | | | |
| Turned Dia. Under 5/32 in. | 1/32 | .006 | 100-125 |
| | 1/16 | .005 | 100-125 |
| Over 5/32 in. | 1/32 | .012 | 100-125 |
| | 1/16 | .010 | 100-125 |

flash pickling; although for purposes other than those requiring a bright surface, no such operation will be necessary.

✦ ✦ ✦

THE properties obtainable by heat treating these alloys are given along with the tabulated properties for the "as produced" forms. Material having properties near the maximum of the "as produced" ranges will, when properly heat treated, develop properties near the maximum of the "heat treated" ranges; while material having properties near the minimum of the "as produced" ranges will, of course, develop properties near the lower limit for heat treated material.

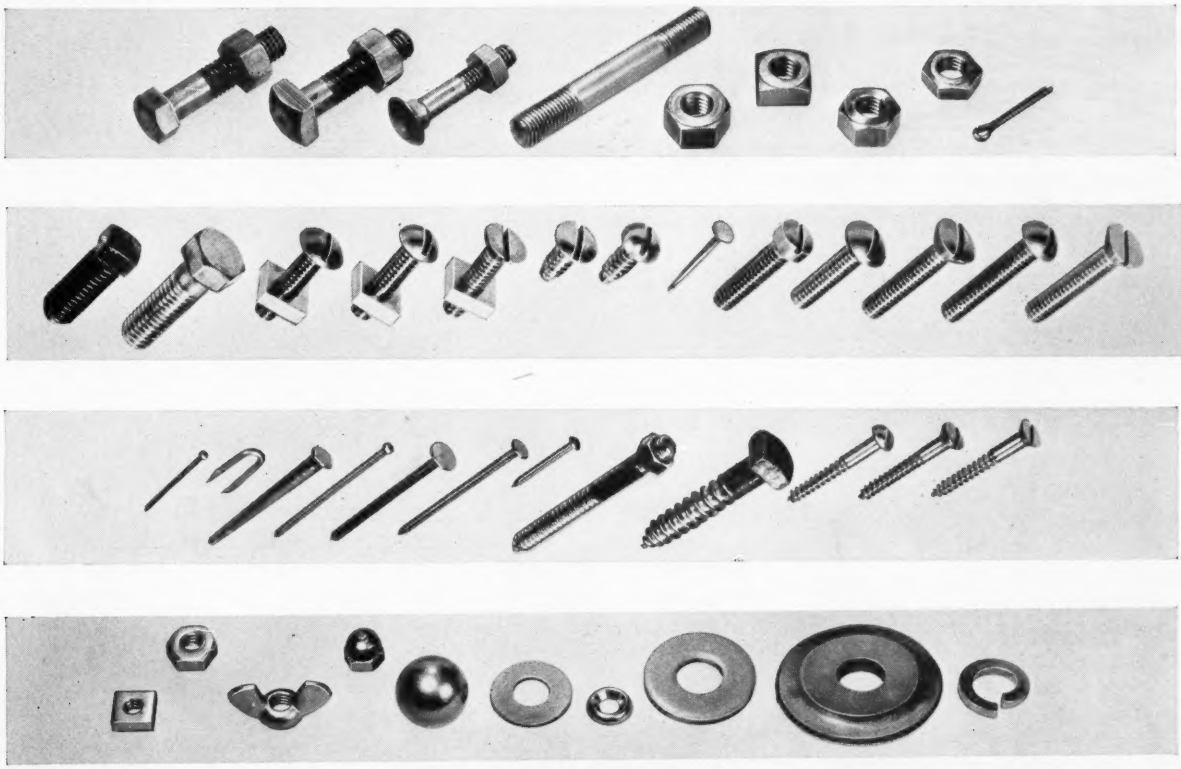
✦ ✦ ✦

MONEL, nickel and Inconel in heavily cold worked form should be stress relieved before being placed into services requiring the best fatigue resistance. Monel and nickle springs can be stress relieved best at 700°-750° F., while less heavily cold worked material can be relieved at temperatures up to 1000° F. without danger of annealing. Inconel springs should be relieved at 800°-850° F., while cold drawn rods or tubes may be relieved at temperatures up to 1200° F. One half hour to one hour is sufficient for this treatment, the longer time being used in conjunction with the lower temperatures.

✦ ✦ ✦

THESE materials will not discolor when stress relieved at 575° F. but the higher temperatures yield better results, even though discoloration will take place in all but the very best controlled atmospheres.

Fig. 3-7. Representing Wire and Rod Products made from High Nickel Alloys.



To Those Registering and Attending the Wire Association Meetings

THERE WILL BE A REGISTRATION FEE OF $5.00

Admission will be by Badge Only

To Those Registering and Attending the Meetings,

Stenographic Copies of the Discussions will be Available Free.

To All Others, $5.00 per Copy

# Exports and Imports of Wire

**Exports of Iron and Steel Wire Products in July, 1937 and July, 1936**

**(In Gross Tons)**

| | July 1937 | June 1937 | July 1936 |
|---|---|---|---|
| Wire rods | 3,775 | 3,968 | 2,132 |
| Strip steel | 8,411 | 10,300 | 6,052 |
| Plain, black or galvanized iron or steel wire | 7,575 | 4,591 | 3,702 |
| Barbed wire and woven wire fencing | 2,789 | 3,009 | 3,361 |
| Woven wire screen cloth | 219 | 143 | 134 |
| Wire rope | 599 | 517 | ..... |
| Insulated iron or steel wire and cable—see analysis below | | | |
| Other wire and manufactures | 774 | 1,355 | 466 |
| Wire nails | 1,760 | 1,966 | 772 |
| Tacks | 67 | 24 | 31 |
| Other nails, including staples | 173 | 217 | 141 |
| Bolts, machine screws, nuts, rivets and washers | 969 | 1,019 | 464 |
| Total these 11 classifications | 27,111 | 27,109 | 17,255 |

**Imports of Iron and Steel Into the United States**

**(In Gross Tons)**

| | | | |
|---|---|---|---|
| Concrete reinforcement bars | 95 | 40 | 364 |
| Hollow bar and drill steel | 146 | 230 | 141 |
| Wire rods | 1,045 | 1,044 | 1,280 |
| Barbed wire | 1,767 | 580 | 949 |
| Round iron and steel wire | 239 | 308 | 464 |
| Telephone and telegraph wire | 2 | 2 | 1 |
| Flat wire and strip steel | 281 | 350 | 172 |
| Other wire | 380 | 734 | 124 |
| Hoops and bands | 3,584 | 2,674 | 2,000 |
| Nails, tacks and staples | 1,827 | 810 | 1,659 |
| Bolts, nuts and rivets | 94 | 18 | 57 |
| Total, these 12 classifications | 9,460 | 6,790 | 7,211 |

**Exports of Insulated Wire and Cable, July, 1937**

| | Foreign | | To U. S. Possessions | |
|---|---|---|---|---|
| | Pounds | Dollars | Pounds | Dollars |
| Insulated iron or steel wire and cable | 28,467 | $ 5,356 | 6,291 | $ 1,273 |
| Rubber-covered wire | 455,954 | 132,125 | 51,815 | 15,033 |
| Copper weatherproof wire | 354,478 | 64,472 | 73,182 | 14,610 |
| Copper telephone cable | 15,023 | 3,189 | 69,921 | 9,027 |
| Other insulated copper wire | 442,165 | 130,987 | 43,750 | 13,402 |
| Nickel-chrome electric resistance wire | 23,495 | 35,803 | ..... | ..... |
| Total, these 6 classifications | 1,319,582 | $371,932 | 244,959 | $53,345 |

## Pig Iron and Ingot Shipments Increase Sharply

AGAINST the June totals, exports in July registered increases in 46 items and declines in 19. The most pronounced gain from the standpoint of tonnage (63,244 tons; 60.1 percent) resulted in pig iron shipments, followed by those in steel ingots (26,563 tons; 134.5 percent), plate (15,365 tons; 46.9 percent) tin plate (11,232 tons; 48.4 percent), plain shapes (10,756 tons; 92.5 percent), black steel sheets (7,115 tons; 28.4 percent), and steel bars (6,280 tons; 49.6 percent).

✦ ✦ ✦

## Pig Iron Leading Product Shipped in July

IN July, pig iron continued to lead as the outstanding product shipped on a tonnage basis, its total (168,538 tons) going chiefly to Japan (84,152), the United Kingdom (66,402), China (7,911), France (4,000), Germany (1,928), and Belgium (1,918). Plate (48,121 tons) ranked next and was taken mostly by Japan (9,194), Sweden (8,391), Canada (5,489), Mozambique (3,895), China (3,201), Finland (2,905), and the Union of South Africa (2,266). Then came steel ingots (46,318 tons), the bulk going to Japan (40,383), British India (3,211), the United Kingdom (1,000), and China (1,000). Following was tin plate —the leader from the standpoint of value—whose 34,439 tons went chiefly to Japan (4,224), Kwantung (3,527), China (3,401), the Netherlands (2,317), Brazil (2,255), and the Union of South Africa (1,774). Ranking next, black steel sheets (32,144 tons) were taken principally by Canada (7,672), Japan (4,283), Netherlands East Indies (3,670), Mexico (2,572), Soviet Union (1,924), and the Union of South Africa (1,473). Plain shapes (22,379 tons) came next and for the most part went to Canada (7,391), Japan (5,822), and China (4,278). Seventh in importance were steel bars (18,950 tons) taken chiefly by Japan (3,981), the United Kingdom (2,614), Canada (2,336), and China (1,609).

✦ ✦ ✦

## Far East Continued to Lead As Outlet

THE Far East continued in July to lead as an outlet for American semifinished and finished iron and steel products taking a total of 215,532 tons in accounting for 46.7 percent of the aggregate 461,421-ton export trade against 45.1 percent of all June shipments. Europe's trade of 116,705 tons followed and made up 25.3 percent of all shipments (23.2 percent), while following was North and Central America and the West Indies whose receipts of 72,741 tons accounted for 15.8 percent of the aggregate (20.4 percent). Fourth-ranking was South America which received shipments amounting to 38,452 tons, or 8.3 percent (9.2 percent). Africa came next with a trade of 17,991 tons, or 3.9 percent (2.7 percent).

✦ ✦ ✦

## Japan Continues To Be Leading Individual Market

IN July, Japan imported from the United States 158,844 tons of finished and semifinished iron and steel products, thereby retaining its leading position. Of this total, the outstanding volumes were registered in pig iron (84,152 tons), steel ingots (40,383), plate (9,194), plain shapes (5,822), black steel sheets (4,283), tin plate (4,224), and steel bars (3,981). The United Kingdom ranked as the second purchaser taking in all 74,012 tons in which the predominating products were pig iron (66,402), steel bars (2,614), ingots (1,000), and cold-

rolled strip steel (876). Canada's trade of 46,713 tons (including practically the full range of products exported) was chiefly skelp (10,821), black steel sheets (7,672), plain shapes (7,391), plate (5,489), steel bars (2,336), and hot-rolled strip steel (2,250). China was next with a 23,077-ton total of mostly pig iron (7,911), plain shapes (4,278), tin plate (3,401), plate (3,201), steel bars (1,609), and ingots (1,000). The Union of South Africa stepped up its purchases considerably to a total of 11,079 tons, the bulk of which being plate (2,266), tin plate (1,774), black steel sheets (1,473), steel bars (887), and barbed wire (536). Mexico was sixth in importance with purchases aggregating 10,852 tons in a wide-spread trade, the outstanding products being black steel sheets (2,572), tin plate (1,360), rails (789), welded black steel pipe (612), ingots (562), and steel sheets (454).

✦ ✦ ✦

### July Import Volume Upward Slightly—Value Lower

IRON and steel imports (excluding scrap) in July aggregated 41,188 tons valued at $2,084,401. While slightly higher (3.7 percent) in volume than in June, the value recorded a 5.8 percent decline. In comparison with the July 1936 trade (38,350 tons valued at $1,600,760) increases of 7.4 percent in volume and 30.2 percent in value were registered.

✦ ✦ ✦

### Pig Iron Chief Import Product

PIG iron receipts in July (8,310 tons) represented the highest individual trade on a tonnage basis and came mostly from British India (5,269), the Netherlands (2,377), and Canada (664). Then were shapes (7,486 tons) taken chiefly from Belgium (6,001), and France (1,160). Following were solid and hollow bars (4,823 tons) imported principally from Belgium (3,220), France (828), and Sweden (492). Hoops and bands (3,689 tons) ranked next, the bulk being purchased from Belgium (3,157), France (283) and Germany (247). Fifth-ranking was spiegeleisen (3,440 tons) received from Canada (3,090) and Norway (350). Ferromanganese (2,598 tons) ranked next, the outstanding suppliers being Norway (2,064), and Canada (431).

✦ ✦ ✦

### Belgium Still Main Factor in Import Trade

IN July, Belgium continued to lead in the supply of iron and steel products (excluding scrap) to the American market, accounting for 13,806 tons in which the outstanding products were shapes (6,001), solid and hollow bars (3,220), and hoops and bands (3,157). Germany followed, its aggregate (6,253 tons) being mostly pipe (1,498), nails, tacks, and staples (1,448), barbed wire (1,241), shapes (1,160), and solid and hollow bars (828). British India's total (5,269 tons) was all pig iron. Canada, the next supplier of importance, sent in 5.016 tons of mostly spiegeleisen (3,090), pig iron (664), rails (496), and ferromanganese (431). Sweden followed with a 2,490-ton share consisting of principally wire rods (886), solid and hollow bars (492), and pipe (341). Sixth in importance, France shared to the extent of 2,462 tons made up mostly by shapes (1,160), solid and hollow bars (829), and hoops and bands (283).

✦ ✦ ✦

THE July CARD CLOTHING TOTALS were 40,413 square feet and $58,605 in comparison with 36,198 square feet and $59,713 in the previous month and came from the United Kingdom (25,649 square feet and $44,403), France (9,468 square feet and $5,495), Germany (3,449 square feet and $5,977), and Belgium (1,847 square feet and $2,730).

✦ ✦ ✦

WIRE HEDDLE receipts at 1,628,000 pieces compared with 1,336,000 pieces and were supplied by Japan (1,008,000), Switzerland (258,000), Belgium (212,000), and France (150,000).

IMPORTS of WIRE FENCING AND NETTING of the galvanized before weaving grade totaled 45,000 square feet which all came from Belgium. Of the galvanized after weaving, 1,614,800 square feet were received from Belgium (1,235,00), and the Netherlands (379,800) in comparison with 1,023,580 square feet in June.

✦ ✦ ✦

FOURDRINIER AND OTHER PAPER MAKING WIRE imports at 80,666 square feet compared with 61,841 square feet in June, the bulk coming from Germany (44,078), Austria (25,939), Switzerland (7,355), and France (6,294).

✦ ✦ ✦

### Exports and Imports

EXPORTS of iron and steel wood screws during July, 1937 totaled 15,713 gross valued at $4,113. Of this total France took 2,917 gross valued at $592; Mexico 2,464 gross valued at $569; Colombia 2,240 gross valued at $391; Cuba 1,715 gross valued at $404; New Zealand 1,100 gross valued at $264; Brazil 805 gross valued at $414.

✦ ✦ ✦

EXPORTS of brass wood screws during the same month totaled 11,945 gross valued at $5,455. Of this total Canada took 7,728 gross valued at $2,902; Panama 968 gross valued at $491; Argentina 706 gross valued at $262; France 476 gross valued at $524; Cuba 254 gross valued at $130; Costa Rica 252 gross valued at $88.

✦ ✦ ✦

IMPORTS of wood screws during the same month totaled 52,198 gross valued at $3,303. Of this total Japan supplied 30,148 gross valued at $1,684; Belgium 22,050 gross valued at $1,619.

**The 1937 Meeting of the Wire Association Will be Held at Atlantic City, N. J. October 18 to 22, 1937**

# Outstanding Personalities of the Wire Industry

### C. E. Johnson, Superintendent, Rod and Wire Mills, Bethlehem Steel Co., Sparrows Point, Md.

THE Bethlehem Steel Company recently announced the appointment of C. E. Johnson as superintendent of rod and wire mills at the Sparrows Point plant, succeeding the late John Mordica.

✦ ✦ ✦

MR. Johnson graduated from Michigan College of Mines as a Mining Engineer in 1923 and went directly with Bethlehem. After a two months' "loop" course he worked from 1923 to 1925 in the Open Hearth Department. From 1925 to 1926 he worked in construction in the building of the Rod and Wire Mill and was assistant superintendent of the Rod and Wire Mill until the recent change.

✦ ✦ ✦

### Roy W. Mackay, Assistant Superintendent, Rod and Wire Mills, Bethlehem Steel Co., Sparrows Point, Md.

MR. ROY W. MACKAY, recently appointed assistant superintendent of the rod and wire mills of the Bethlehem Steel Company, Sparrows Point, Md., was graduated from M.I.T. in 1918 as Electrical Engineer. He instructed in Physics at Georgia School of Technology from 1918 to 1919, Oil Field construction — Mid-Continent fields from 1919-21; with Davison Chemical Company as Experimental Engineer 1921-22; and with Bethlehem Steel Company in the Electrical, Metallurgical and Rod and Wire Departments from 1922-1937.

✦ ✦ ✦

### G. H. Bendell Superintendent, Waukegan Plant, American Steel & Wire Co.

GEORGE H. BENDELL has been appointed Superintendent of the Waukegan plant of the American Steel & Wire Company. Mr. Bendell has been Assistant Superintendent and succeeds the late W. E. Acomb.

GEORGE H. BENDELL
Superintendent, Waukegan Plant, American Steel and Wire Co.

MR. Bendell has been with the United States Steel Corporation since 1907, having started with the Illinois Steel Company as an inspection clerk. During this period he has held many positions which give him a valuable background for his new duties. He first came to the American Steel & Wire Company last year when he was appointed Assistant Superintendent of the Waukegan Works.

✦ ✦ ✦

MR. Bendell was born in Hammond, Ind., in 1891, but when he was quite young his family moved to Chicago where he received his education. He is a member of the American Society for Metals, is married and has two sons.

✦ ✦ ✦

### S. R. Snow, Assistant Superintendent, Waukegan Plant, American Steel & Wire Co.

S. R. SNOW, who has been foreman of the wire mill, has been appointed Assistant Superintendent.

✦ ✦ ✦

MR. Snow, who succeeds Mr. Bendell as Assistant Superintendent, has been with the American Steel & Wire Company for fifteen years at Waukegan. He started with the Wire Company in 1912 at DeKalb, Ill.

✦ ✦ ✦

### Frederick R. Ward, Assistant District Manager, Chicago District, Republic Steel Corp.

J. L. HYLAND, district manager of the Chicago district of Republic Steel Corp., announced the appointment of Frederick R. Ward as assistant district manager, effective Sept. 1st.

✦ ✦ ✦

MR. Ward's first position was as a chemist for the Corrigan McKinney Steel Co., Cleveland, and he left there to become chief chemist for the American Manganese Co. In 1919 he became superintendent and meterologist for the Tennessee Manganese Co. From there he became superintendent of operations for the Graham Furnace Corp. in 1922, and in 1923 he went with the Jones & Laughlin Steel Corp. as superintendent of the bars mills at the Pittsburgh works.

✦ ✦ ✦

MR. Ward went to the Chicago district of Republic Steel Corp. on July 13, 1936, as assistant superintendent of the finishing mills and special process division, which position he held until his present appointment.

✦ ✦ ✦

### Charles Malone, General Superintendent of the Stevens Metal Products Co.

CHARLES MALONE, former assistant general superintendent of the Newburgh works of the American Steel & Wire Company, has been appointed general superintendent of the Stevens Metal Products Company of Niles, Ohio.

✦ ✦ ✦

MR. WAYNE Z. FRIEND has been added to the development and research staff of the International Nickel Co., Inc., New York.

✦ ✦ ✦

MR. Friend will devote most of his time to technical service on corrosion resisting materials,

# THE WIRE ASSOCIATION — 1937

Vice President
**F. A. WESTPHAL**
Superintendent, Wire Mills
Sheffield Steel Corp.,
Kansas City, Mo.

President
**RALPH K. CLIFFORD**
Works Manager,
Continental Steel Corp.,
Kokomo, Indiana

Vice President
**E. W. CLARK**
Mechanical Engineer,
Wire & Cable Section,
General Electric Co.,
Schenectady, N. Y.

RICHARD E. BROWN—Secretary

## BOARD OF DIRECTORS

C. S. Barningham, Sales Manager, New England Butt Company, Providence, R. I.

J. K. Boll, Manager, Wire Sales, Wheeling Steel Corp., Wheeling, W. Va.

R. E. Brown, Publisher, WIRE AND WIRE PRODUCTS 17 East 42nd Street, New York, N. Y.

John C. Callaghan, Works Manager, Canada Works, Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

H. B. Carnahan, Assistant Works Manager, Canada Wire and Cable Company, Toronto, Ontario, Canada.

E. W. Clark, Mechanical Engineer, Wire & Cable Section, General Electric Co., Schenectady, N. Y.

Ralph K. Clifford, Works Manager, Continental Steel Corp., Kokomo, Ind.

M. A. Kent, Manufacturing Director, General Cable Corp., New York, N. Y.

Kenneth B. Lewis, Consulting Engineer 43 Midland Street, Worcester, Mass

B. L. McCarthy, Metallurgist, Wickwire Spencer Steel Co. Station "B", Buffalo, N. Y.

W. D. Pierson, Secretary, Waterbury Farrel F'dry & Machine Co., Waterbury, Conn.

R. S. Simmons, General Metallurgist, Keystone Steel & Wire Co., Peoria, Ill.

F. A. Westphal, Supt., Wire Mills, Sheffield Steel Corp., Kansas City, Mo.

THE Wire Association is a non-profit organization of wire mill executives, superintendents and foremen. It also includes plant engineers, traffic men, credit men, salesmen, and all others engaged in the wire industry, together with manufacturers, and other interested people who have something to sell to the wire mill or some service to render for pay.

✦ ✦ ✦

THERE are separate divisions for all the separate major interests in the wire industry, steel, iron, brass, copper, alloy, and precious metals, together with divisions relating to drawing, fabricating, forming, spring making, wire cloth, wire rope, insulated wire, electric wire and cable and all other forms of wire and wire products.

FREDERICK A. WESTPHAL
Superintendent of Wire Mills, Sheffield Steel Corp., Kansas City, Mo., Vice President, The Wire Association

RALPH K. CLIFFORD
Works Manager, Continental Steel Corp.
President, The Wire Association

✦ ✦ ✦

## ACTIVITIES:

ITS specific purpose is to improve production methods and afford a clearing house for ideas on management problems, technical problems, and research work in all phases of practical wire drawing and wire working, and to develop and maintain friendly relations among the members.

✦ ✦ ✦

THE Association functions along the following lines:

1. The use of the Association headquarters as a central clearing house for information and data of all kinds which may be of interest to members.
2. The exchange of ideas on processes of production including machinery, technical processes, etc.
3. The establishment and maintenance of friendly relations among the members of the association and the development of sectional and national meetings to discuss matters of mutual interest.
4. Studies of production methods and analysis of production costs.
5. Developments in the use of new materials and new applications of existing materials and by-products.
6. Research and collection of information on personnel management, including such factors as labor turnover, seasonal changes, in the demand for employees, wage scales, etc.
7. Standardization and simplification as a means for the effective elimination of waste.
8. Such other subjects as may be determined upon.

E. W. CLARK
Mechanical Engineer, Wire and Cable Section, General Electric Co., Schenectady, N. Y., Vice President, The Wire Association

# All Wire Mill Men Are Invited to Attend The Wire Association 1937 Meeting and Exhibition

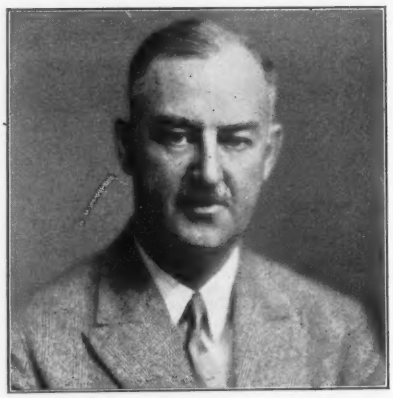
## At Atlantic City, N. J., October 18, 19, 20, 21, 22, 1937

### In Association With the National Metal Congress

WIRE ASSOCIATION HEADQUARTERS AND MEETINGS WILL BE AT THE HOTEL AMBASSADOR

✦ ✦ ✦

Every wire mill production executive engaged in the manufacture or fabrication of wire and wire products of any kind is invited to join the Wire Association and attend these meetings. ✦ ✦ ✦ ✦ ✦ ✦



JOHN C. CALLAGHAN
Works Manager, Canada Works, Steel Co. of Canada. Chairman, Program Committee.

In addition to a program of research papers, a splendid opportunity is offered for informal discussions. For this purpose Wire Association Headquarters in the Hotel Ambassador are open from 9 A. M. to 11 P. M. daily. ✦ ✦ ✦ ✦ ✦ ✦

Wm. H. Bassett, Jr., Manager,
Metallurgical Development,
Anaconda Wire & Cable Co.,
Hastings-On-Hudson, N. Y.

E. W. Clark, Mechanical Engineer,
Wire and Cable Section,
General Electric Co., Schenectady, N. Y.

### PROGRAM COMMITTEE

John C. Callaghan, Works Manager,
Canada Works,
Steel Company of Canada, Ltd.,
Hamilton, Ont. Canada, Chairman

✦ ✦ ✦

### PAPERS COMMITTEE

#### Cold Working Division

B. L. McCarthy, Chief Metallurgist,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.
Chairman of Division

H. M. Brightman, Asst. to President,
Columbia Steel & Shafting Co.,
Carnegie, Pennsylvania

D. D. Buchanan, Asst. Gen. Manager,
Union Drawn Steel Company,
Massillon, Ohio

Louis S. Cooch, Metallurgist,
Buffalo Bolt Company,
North Tonawanda, N. Y.

W. H. Crawford, Resident Manager,
Eaton Manufacturing Co.,
Massillon, Ohio

Chas. Fassinger, Sr., Vice Pres.,
Oliver Iron & Steel Corp.,
Pittsburgh, Pa.

R. W. Krise, Vice Pres. & Gen. Mgr.,
Milton Mfg. Co., Milton, Pa.

Richard L. Wilcox, Vice President,
Waterbury Farrel Foundry & Mach. Co.,
Waterbury, Connecticut.

B. L. McCarthy, Chief Metallurgist,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.

R. E. Brown, President,
"WIRE AND WIRE PRODUCTS."
New York, N. Y.

#### Non Ferrous Division

E. W. Clark, Mechanical Engineer,
Wire and Cable Section,
General Electric Co., Schenectady, N. Y.
Chairman of Division

Wm. H. Bassett, Jr., Manager,
Metallurgical Development,
Anaconda Wire & Cable Co.,
Hastings-On-Hudson, N. Y.

H. B. Carnahan, Asst. Works Mgr.,
Canada Wire & Cable Co., Ltd.,
Toronto, Ont., Canada.

L. E. Dunkelberger, Chief Engineer,
Reynolds Wire Company,
Dixon, Ill.

D. Horsfall, Works Manager,
Canada Wire & Cable Co., Ltd.,
Toronto, Ontario, Canada.

Carl Rolle, Mechanical Engineer,
International Nickel Co., Inc.,
New York, N. Y.

#### Steel and Ferro Alloys Division

F. A. Westphal, Supt., Wire Mills,
Sheffield Steel Corp., Kansas City, Mo.
Chairman of Division

A. F. Anjesky, Sales Manager,
Cleveland Tramrail Div. of the
Cleveland Crane & Engr'g. Co.,
Wickliffe, Ohio

L. Atkinson, Superintendent,
Frost Steel & Wire Co., Ltd.,
Hamilton, Ontario, Canada.

Rodman R. Tatnall, Engineer,
Wickwire Spencer Steel Co.,
Worcester, Mass.

Earle H. Thomas, Superintendent,
Geo. W. Prentiss & Co.,
Holyoke, Mass.

Leslie C. Whitney, Chief Metallurgist,
Copperweld Steel Corp.,
Glassport, Pa.

**Make Your Plans Now to Come and Participate in the Discussions.**
**For detailed information address RICHARD E. BROWN, Secretary**

17 EAST 42nd ST. THE WIRE ASSOCIATION New York, N. Y.

# ✣ PROGRAM ✣

## Monday, October 18, 1937 at Hotel Ambassador, Atlantic City, N. J.

**A. M.—Registration—"Get Together"**

**1 P. M. Directors' Meeting—Program Committee Meeting and Lunch**

✦ ✦ ✦

# The Technical Sessions

**MONDAY, TUESDAY, WEDNESDAY AND THURSDAY, OCTOBER 18-19-20-21, 1937**

**(All Research Papers Will Be Preprinted in the October Issue of Wire and Wire Products)**

---

**THERE WILL BE A REGISTRATION FEE OF $5.00 FOR THOSE ATTENDING THESE TECHNICAL SESSIONS AND INFORMAL MEETINGS**

**ADMISSION WILL BE BY BADGE ONLY**

**To those Registering and Attending the Meetings stenographic copies of the discussions will be available free. To all others $5.00 per copy**

**MONDAY, OCTOBER 18, 1937**
**Afternoon Session, 2:00 P. M.**

**F. A. Westphal, Supt. of Wire Mills**
**Sheffield Steel Co., Kansas City, Mo.**
**Chairman of Meeting**

✦ ✦ ✦

**ADDRESS: NEW DEVELOPMENTS IN MATERIAL HANDLING FOR WIRE MILLS**
**By A. F. Anjeskey, Sales Manager**
**Cleveland Tramrail Division, Cleveland Crane & Engineering Co., Wickliffe, Ohio**

✦ ✦ ✦

**TUESDAY, OCTOBER 19, 1937**
**Morning Session, 9:30 A. M.**

**Dr. S. A. Braley, Industrial Fellow**
**Mellon Institute of Industrial Research, University of Pittsburgh**
**Pittsburgh, Pa.**
**Chairman of Meeting**

✦ ✦ ✦

**PAPER: A. C. ELECTRO-PICKLING**
**By Allan B. Dove, Chemical Engineer**
**Canada Works, The Steel Company of Canada, Ltd., Hamilton, Ont., Canada**

✦ ✦ ✦

**PAPER: HANDLING WASTE ACIDS FROM PICKLING OPERATIONS**
**By H. E. Klein, Engineer, Chemical Industry**
**B. F. Goodrich Company, Akron, Ohio**

✦ ✦ ✦

**PAPER: LIME IN WIRE DRAWING**
**By D. E. Washburn, Chief Chemist**
**American Lime & Stone Div. of Warner Co., Bellefonte, Pa.**

✦ ✦ ✦

**MOTION PICTURE: "THE MAKING OF STEEL WIRE," BETHLEHEM STEEL CO.**

✦ ✦ ✦

**Afternoon Session, 2:00 P. M.**

**R. S. Simmons, General Metallurgist**
**Keystone Steel & Wire Co., Peoria, Ill.**
**Chairman of Meeting**

PAPER: A METALLURGICAL STUDY OF THE FACTORS AFFECTING THE QUALITY OF GALVANIZING
By R. W. Sandelin, Chief Metallurgist
Atlantic Steel Company, Atlanta, Ga.

✦ ✦ ✦

PAPER: FATIGUE PROPERTIES OF HELICAL SPRINGS
By R. R. Tatnall, Engineer
Morgan Works, Wickwire Spencer Steel Co., Worcester, Mass.

✦ ✦ ✦

WEDNESDAY, OCTOBER 20, 1937

## Simultaneous Meetings of Ferrous and Non-Ferrous Divisions All Day

Morning Sessions, 9:30 A. M.

### Ferrous Division

C. L. Harvey, Chief Metallurgist
Lamson & Sessions, Cleveland, Ohio
Chairman of Meeting

✦ ✦ ✦

PAPER: COLD HEADING
By L. S. Cooch, Metallurgist
Buffalo Bolt Company, North Tonawanda, N. Y.

✦ ✦ ✦

PAPER: DEVELOPMENTS IN COLD HEADING AT GENERAL ELECTRIC
By A. R. Ryan, Industrial Heating Engineer
General Electric Co., Schenectady, N. Y.

✦ ✦ ✦

### Non-Ferrous Division

E. W. Clark, Chief Engineer
Wire and Cable Division, General Electric Co.
Schenectady, N. Y.
Chairman of Meeting

PAPER: THE NEED OF A BETTER QUALITY OF COPPER IN APPARATUS MANUFACTURE
By L. H. Burnham, Engineer
Transportation Div., General Electric Company, Pittsfield, Mass.

PAPER: THE MANUFACTURE OF FOURDRINIER WIRES
By Hugh E. Brown, Director of Research
W. S. Tyler Company, Cleveland, Ohio

✦ ✦ ✦

Afternoon Sessions, 2:00 P. M.

### Ferrous Division

L. H. Winkler, Metallurgical Engineer
Bethlehem Steel Co., Bethlehem, Pa.
Chairman of Meeting

PAPER: ABNORMAL GRAIN GROWTH AND THE ANNEALING OF LOW CARBON STEEL WIRE
By B. L. McCarthy, Chief Metallurgist
Wickwire Spencer Steel Company, Buffalo, N. Y.

✦ ✦ ✦

DISCUSSION: THE FLASH BAKER
By Kenneth B. Lewis
Consulting Wire Mill Engineer, Worcester, Mass.

## Non-Ferrous Division

H. B. Carnahan, Asst. Works Manager
Canada Wire & Cable Co., Toronto, Canada
Chairman of Meeting

PAPER: PRODUCTION OF COPPER FROM MINE TO MILL
By Wm. H. Bassett, Jr., Manager, Metallurgical Development
Anaconda Wire & Cable Co., Hastings-on-Hudson, N. Y.

✦ ✦ ✦

MOTION PICTURE: NORANDA ENTERPRISES

✦ ✦ ✦

At 4:30 P. M., Wednesday afternoon all Technical Sessions will terminate for the day and be immediately followed by the annual meeting of the Wire Association. At this meeting will be made the Award of The Wire Association Medal, by John C. Callaghan, Chairman of Program Committee.

✦ ✦ ✦

Evening—The Ambassador—7:00 P. M.
Annual Dinner—Stag-Smoker

DINNER COMMITTEE

R. L. Hamaker, Dist. Sales Manager
Warner Company
New York, N. Y.
Chairman

A. R. Zapp, Manager
Firthaloy Division
Firth Sterling Steel Co.
McKeesport, Pa.

✦ ✦ ✦

THURSDAY, OCTOBER 21, 1937

Morning Session, 9:30 A. M.
W. F. Burchfield, Development Engineer
Development and Research Division, International Nickel Co., New York
Chairman of Meeting

PAPER: NICKEL AND NICKEL BASE ALLOYS IN WIRE AND ROD PRODUCTS
By Carl Rolle, Development and Research Division
International Nickel Co. Inc., New York, N. Y.

✦ ✦ ✦

PAPER: NOTES ON THE ANNEALING OF NICKEL SILVER WIRE IN COILS
By T. C. Merriman, Metallurgist
Seymour Manufacturing Co., Seymour, Conn.

✦ ✦ ✦

Afternoon Session, 2:00 P. M.
D. D. Buchanan, Assistant General Manager
Union Drawn Steel Co., Massillon, Ohio
Chairman of Meeting

PAPER: COLD DRAWN BARS
By D. W. McDowell, Metallurgist
Union Drawn Steel Company, Chicago, Illinois

✦ ✦ ✦

PAPER: "DOUBLE TREATING" TRACK AND FROG BOLTS
By Chas. Fassinger, Vice-President
Oliver Iron & Steel Corp., Pittsburgh, Pa.

✦ ✦ ✦

MOTION PICTURE: "THE MAKING OF STEEL WIRE," BETHLEHEM STEEL CO.

ALL MEETINGS WILL BE HELD AT THE AMBASSADOR HOTEL, ATLANTIC CITY, N. J.

## Convention Notes

AT the Wire Association Meeting this year there will be a slight deviation from past practices. Instead of presenting a prepared paper, Mr. Anjeskey of the Cleveland Tramrail Division of the Cleveland Crane & Engineering Company, will give an extemporaneous illustrated talk showing layouts and views of the latest type of material handling equipment used in rod and wire mills; Mr. Kenneth B. Lewis will give a talk on "The Flash Baker", one of the newest developments in baking and will be prepared to answer any questions which may be asked him in this connection.

✦ ✦ ✦

THE paper "Cold Heading" by L. S. Cooch, Metallurgist of the Buffalo Bolt Company, was not preprinted because of the illness of Mr. Cooch which prevented him from submitting it before the publication deadline. The paper will, however, be presented at the meeting and published in the November issue of WIRE AND WIRE PRODUCTS. The same applies to the paper by Mr. H. E. Klein of the B. F. Goodrich Company, entitled "Handling Waste Acids from Pickling Operations".

✦ ✦ ✦

## Wire Machinery Builders Association

THE annual meeting of the Wire Machinery Builders' Association will be held as usual during the Convention of the Wire Association at Atlantic City, New Jersey, October 18th to 22nd inclusive.

✦ ✦ ✦

THE meeting will probably be held Wednesday, October 20th in the form of a luncheon. All members of the Association are requested to be present.

✦ ✦ ✦

## Morrison Engineering Company

THE Morrison Engineering Company will have one of their new Flash Bakers in operation at Booth C-83 at the Wire Association Convention at Atlantic City. Visitors interested in this new process will be able to use rods and wire actually baked in a practical demonstration of the new baker.

✦ ✦ ✦

## E. F. Houghton & Company

BY means of graphic displays of its entire line of heat-treating salts at the metals Exposition in Atlantic City, E. F. Houghton & Company, Philadelphia, celebrates the inception of its heat-treating salt business 25 years ago.

✦ ✦ ✦

REVEALING the outcome of extensive field tests over the past two years, Houghton officials, metallurgists, and members of the Metal Research Staff will discuss publicly for the first time the company's new and comprehensive line of heat-treating salts. This includes some 19 formulae, of which 8 are recent developments.

✦ ✦ ✦

INTERESTING case histories and performance records of the new salts will be given. The company's complete line of carbur-

(*Please turn to Page 678*)

# Wire Association Membership -- 1937

AKIN, W. M., Asst. to Pres.,
Laclede Steel Co.,
St. Louis, Mo.

ALDRIDGE, D. W., Tech. Supt. Wire Mills,
British Insulated Cables, Ltd.,
Prescot, Lancashire, England.

ANDZULIS, JOSEPH M., Foreman,
The Bridgeport Screw Co.,
Bridgeport, Conn.

ANJESKEY, A. F., Sales Mgr.,
Cleveland Tramrail Div. of the
Cleveland Crane & Eng. Co.,
Wickcliffe, Ohio.

ATKINSON, L., Superintendent,
Frost Steel & Wire Co., Ltd.,
Hamilton, Ontario, Canada.

BABB, C. W., Factory Supt.,
The Columbus Bolt Works Co.,
Columbus, Ohio.

BAKER, DAVID, JR.,
Metallurgical Engineer,
Philadelphia, Pa.

BARNINGHAM, CHAS. S., Sales Mgr.,
New England Butt Co.,
Providence, R. I.

BARTLETT, J. C., Proprietor,
Bartlett Hair Spring Wire Co.,
North Haven, Conn.

BASSETT, CYRUS W., Engineer,
Elevator Supplies Co., Inc.,
Rahway, N. J.

BASSETT, WM. H., JR., Manager,
Metallurgical Development,
Anaconda Wire and Cable Co.,
Hastings-on-Hudson, N. Y.

BEACH, HAROLD K., Engr.,
Phelps Dodge Copper Products Corp.,
American Copper Products Corp.,
Elizabeth, N. J.

BEAMAN, P. ALDEN, Sales Mgr.,
Wire Machinery Dept.,
Morgan Construction Co.,
Worcester, Mass.

BEARDSLEE, K. R., General Sales Mgr.,
Carboloy Company, Inc.,
Detroit, Mich.

BEESON, J. K., Asst. Gen. Supt.,
Pittsburgh Steel Co.,
Monessen, Pa.

BEIGHLEY, ANSON E., Sales Repr.,
American Chemical Paint Co.,
Cleveland, Ohio.

BEKAERT, L. A., Managing Director,
S. A. Trefileries Leon Bekaert,
Sweveghem, Belgium.

BENNETT, H. W., President,
Belleville Wire Rope Co.,
Belleville, N. J.

BEVERIDGE, N. G., Mgr., Wire Works Dept.,
Union Steel Corp., (S. A.) Ltd.,
Vereeniging, Transvaal, South Africa.

BLOUNT, HARRY, Development Engineer,
Western Electric Co.,
Baltimore, Md.

BLOUNT, WM. H., Treasurer,
Sleeper & Hartley, Inc.,
Worcester, Mass.

BOGMAN, MAJOR JAMES H. BEALS,
Signal Corps., U. S. Army,
Chicago Procurement District,
Chicago, Ill.

BOLL, JOHN K., Manager, Wire Sales Div.,
Wheeling Steel Corp.,
Wheeling, West Va.

BOND, FRANK A., Vice-Pres.,
The McKay Company,
Pittsburgh, Pa.

BOSWIN, GEO. A., Gen. Sales Mgr.,
Cable Reel Department,
Stevens Metal Products Co., Niles O.

BOULIN, VICTOR J., Manager,
Vianney Wire Die Works,
New York, N. Y.

BRALEY, S. A., Fellow,
Mellon Institute of Industrial Research,
Pittsburgh, Pa.

BRERETON, C. F., Metallurgist,
Richard Johnson & Nephew, Ltd.,
Manchester, England.

BRIGHTMAN, H. M., Asst. to President,
Columbia Steel & Shafting Co.,
Carnegie, Pa.

BROADDUS, E. T., Representative,
Firth-Sterling Steel Co.,
Chicago, Ill.

BRODEN, EDWIN H., Mgr., Wire Mills,
American Steel & Wire Co.,
Pittsburgh, Pa.,

BRODEN, G. A., President,
Broden Construction Co.,
Cleveland, Ohio.

BRONSON, W. D., Sales Representative,
Union Wire Die Corp.,
Chicago, Ill.

BROWN, HUGH E., Director of Research,
The W. S. Tyler Co.,
Cleveland, Ohio.

BROWN, RICHARD E., Publisher,
WIRE & WIRE PRODUCTS,
New York, N. Y.

BRUNTON, J. D., President,
Bruntons (Musselburgh), Ltd.,
Musselburgh, Scotland.

BRYANT, F. H., Secretary,
The Western Automatic Machine Screw Co.,
Elyria, Ohio.

BUCHANAN, D. D., Asst. Gen. Mgr.,
Union Drawn Steel Company,
Massillon, Ohio.

BULLOCK, CAPTAIN FRANK W.,
Signal Corps., U. S. Army,
Brooklyn, N. Y.

BUSH, MAJOR GEO. P.,
Signal Corps., U. S. Army,
Office of Chief Signal Officer,
Washington, D. C.

BUTLER, J. F., Supt.,
Milton Mfg. Co.,
Milton, Pa.

CALLAGHAN, JOHN C., Works Mgr.,
Canada Works, Steel Co., of Canada, Ltd.,
Hamilton, Ontario, Canada.

CARNAHAN, H. B., Asst. Works Mgr.,
Canada Wire & Cable Co., Ltd.,
Toronto, Ont., Canada.

CARROLL, JAMES J., President,
Steelcraft Piston Ring Co.,
Detroit, Mich.

CASEY, AUSTIN, Sales Engineer,
Syncro Machine Company,
Newark, N. J.

CASSIDY, LEVI M.,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.

CHAMBRE, LOUIS, Vice-President,
Balloffet Dies & Nozzle Co., Inc.,
Guttenberg, N. J.

CHATTERTON, E. R., Treasurer,
E. W. Twitchell, Inc.,
Philadelphia, Pa.

CLARK, E. W., Mechanical Engineer,
Wire & Cable Section, General Electric Co.,
Schenectady, N. Y.

CLARK, HERBERT B., Vice Pres.,
Union Wire Die Corp.,
Stamford, Conn.

CLIFFORD, RALPH K., General Works Mgr.,
Continental Steel Corp.,
Kokomo, Indiana.

COHN, RALPH F., Asst. to President,
Pines-Winterfront Company,
Chicago, Ill.

CONLEY, G. C., Foreman,
Packard Electric Div.,
General Motors Co., Warren, Ohio.

CONNOR, F. J., Dist. Manager,
Wickwire Spencer Steel Company,
Worcester, Mass.

COOCH, LOUIS S., Metallurgist,
Buffalo Bolt Company,
North Tonawanda, N. Y.

COPPICK, JOHN C., Manager,
Security Fence Co., Ltd.,
Montreal, Canada.

CORBLEY, EDWARD F., Superintendent,
Stewart Hartshorn Co.,
Harrison, N. J.

CORNELIUS TAYLOR,
Asst. Supt. Wire Mill,
Aluminum Co. of Canada, Ltd.,
Shawinigan Falls, P. Q., Canada.

CRAPO, FRED M. Vice Pres.,
Charge Operations,
Indiana Steel & Wire Co.,
Muncie, Ind.

CRAWFORD, W. H., Resident Manager,
Eaton Manufacturing Co.,
Massillon, Ohio.

CREWE, L. C., JR., Foreman Wire Mill,
Bethlehem Steel Co.,
Sparrows Point, Md.

CROSSET, D. A., Treas. & Gen. Mgr.,
Alloy Metal Wire Co.,
Moore, Pa.

CUNY, MAJOR C. D., Signal Corps.,
U. S. Army, Presidio of San Francisco,
San Francisco, Calif.

DAVENPORT, H. D., Superintendent,
Washburn Wire Co.,
New York, N. Y.

DAY, JAMES, Sales Engineer,
Selson Machine Tool Co., Ltd.,
London, S. W. 1, England.

DeKLYN, JOHN H., Superintendent,
U. S. Aluminum Company,
Massena, New York.

DeLORI, JEAN, Managing Director,
Clouterie & Trefileries des Flandres,
Gentbrugge, Lez Gand, Belgium.

DENNIS, M. W., JR., Die Engr.,
Vanadium-Alloys Steel Co.,
Pittsburgh, Pa.

DERN, EMIL, Secretary,
Kelly Wire Die Corp.,
New York, N. Y.

DOMES, VIKTOR, Wire Engineer,
Felten & Guilleaume, A. G.
Bruck A/D Mur, Austria.

DONALD, GEO. E., Superintendent,
Canada Wire & Iron Goods Co.,
Hamilton, Ontario, Canada.

DOYLE, J. A., Vice-President,
W. S. Rockwell Company,
New York, N. Y.

DRAKE, GEO. L., Sales Mgr., Hoist Div.,
Harnischefeger Corp.,
Milwaukee, Wis.

DRIVER, ROBERT O., Vice-President,
Wilbur B. Driver Company,
Newark, N. J.

DUNKELBERGER, L. E., Chief Engineer,
Reynolds Wire Co.,
Dixon, Ill.

EARLY, E. F., Superintendent,
Wickwire Spencer Steel Co.,
Morgan Works, Worcester, Mass.

EATON, R. M., Resident Manager,
Hazard Insulated Wire Works,
Wilkes-Barre, Pa.

EDICK, H. L., Plant Superintendent,
Wickwire Brothers,
Cortland, N. Y.

ELDER, FLINT C., Chief Metallurgist,
American Steel & Wire Company,
Cleveland, Ohio.

ELIAS, H. W., Asst. Mgr., Firthaloy Div.,
Firth Sterling Steel Co.,
McKeesport, Pa.,

FANTONE, CHARLES B., President,
Syncro Machine Company,
Newark, N. J.

FARNSWORTH, W. B., Chief Metallurgist,
Pittsburgh Steel Co., Monessen, Pa.

FASSINGER, CHAS., SR., Vice-President,
Oliver Iron & Steel Corp.,
Pittsburgh, Pa.

FAST, PAUL R., Plant Superintendent,
Belden Manufacturing Co.,
Chicago, Ill.

FIRTH, L. GERALD, Pres. & Gen. Mgr.,
Firth Sterling Steel Co.,
McKeesport, Pa.

FISHER, EDWARD J. P., Metallurgist,
Republic Steel Corp.,
Chicago, Ill.

FOSBURG, HILDOR A., Secretary,
The Meaker Co.,
Chicago, Ill.

FOSS, DR. ING. FEODORE F.,
Assistant to Chairman & Gen. Metallurgist,
Wheeling Steel Corp.,
Wheeling, W. Va.

FRIEDMAN, J. H., Vice-President,
National Machinery Co.,
Tiffin, Ohio.

GAINES, FREDERICK W., 3d, Mech. Eng.
Ajax Manufacturing Co.,
Euclid, Ohio.

GIBBS, C. R.,
American Wire Fabrics Co.,
Mount Wolf, Pa.

GIRVEN, J. E., Wire & Cable Engr.,
Canadian General Electric Co., Ltd.,
Peterborough, Canada.

*(Please turn to Page 664)*


# WIRE ASSOCIATION

## *Welcome To*

## THE

# AMBASSADOR

## OCTOBER 18th TO 23rd

When you come to Atlantic City, make your headquarters at the largest hotel nearest the auditorium . . . The Ambassador. You'll be adding hours of pleasure and enjoyment to your stay by being so close to everything that's going on. And The Ambassador is Atlantic City's finest hotel, located directly on the boardwalk with most guest rooms facing the Atlantic. You'll find everything you want at The Ambassador . . . comfortable rooms at moderate rates . . . fine restaurants . . . indoor swimming pool and other recreational facilities . . . spacious sun decks and public rooms. May we make a reservation for you now?

THE AMBASSADOR, ATLANTIC CITY

WILLIAM HAMILTON
Managing Director

HAROLD E. BAGGS
Convention Manager

MAKE YOUR PLANS NOW TO COME TO THE WIRE ASSOCIATION MEETING

## Wire Association Membership List—1937

(*Continued From Page 663*)

GLADER, FRANK J., President,
Wm. Glader Machine Works,
Chicago, Ill.

GLEASON, W. W., Supt.,
Nachman Spring-Filled Corp.,
Chicago, Ill.,

GORDON, C. S., Wire Development Eng.,
Bell Telephone Laboratories, Inc.,
New York, N. Y.

GOULD, WM., Mechanical Engineer,
New York, N. Y.

GRANGER, L. D., Asst to Vice-Pres.,
Wickwire Spencer Steel Co.,
New York, N. Y.

GRASSELL, P. W., Pres. & Treasurer,
Wilson Steel & Wire Company,
Chicago, Ill.

GUNDSTROM, E. W., Asst. Plant Mgr.,
Rome Cable Corp., Rome, N. Y.

GUSCOTT, LOWELL E., Superintendent,
United Screw & Bolt Corp.,
Cleveland, Ohio.

HAARBAUER, H. W., Supt. Wire Mill,
Townsend Company, New Brighton, Pa.

HAGUE, JOSEPH A., Dist. Sales Mgr.,
Pittsburgh Steel Company,
Cleveland, Ohio.

HAKA, JOHN E., Works Manager,
Midland Wire Corp.,
Tiffin, Ohio.

HAMAKER, R. L., Dist. Sales Manager,
Warner Company,
New York, N. Y.

HAMMITT, S. J., Manager,
Morrison Steel & Wire Co., Ltd.,
Granville Island, Vancouver, B. C., Canada.

HARRISON, N. C., Vice-President,
Atlantic Steel Company,
Atlanta, Ga.

HART, FRANK E., Manager,
Anaconda Wire & Cable Co.,
Marion, Indiana.

HARVEY, C. L., Chief Metallurgist,
Lamson & Sessions Co.,
Kent, Ohio.

HARVEY, L. S., Works Manager,
Platt Brothers & Co.,
Waterbury, Conn.

HENDERSON, KEITH T., Metallurgist,
Broken Hill Proprietary Co., Ltd.,
Port Waratah, Newcastle, N. S. W., Australia.

HERMAN, WM. P., President,
General Insulated Wire Corp.,
Providence, R. I.

HEYN, H. M., Sales Mgr., Chg. Heat
Treating Div., Surface Combustion Co.,
Toledo, Ohio.

HINDS, J. L., President,
Phila. Insulated Wire Co.,
Philadelphia, Pa.

HIRE, HARRY E., Supt. Wire & Insulation
Div., General Electric Co.,
Fort Wayne, Ind.

HITCHCOCK, WM. E., President,
Atlantic Wire Co., Branford, Conn.

HOHL, HENRY, D., V. P. Chg. Production,
Triangle Conduit & Cable Co., Inc.,
Brooklyn, N. Y.

HOLMQUIST, C. W., Plant Engineer,
Copperweld Steel Company,
Glassport, Pa.

HOLMQUIST, JOHN A.
Aliquippa, Pa.

HOLTON, A. E., President,
Essex Wire Corp.,
Detroit, Mich.

HOOVER, J. R., Manager,
Chemical Sales Div., B. F. Goodrich Co.,
Akron, Ohio.

HOPE, R. B., Supt., Rod & Wire Div.,
Wheeling Steel Corp.,
Portsmouth, Ohio.

HORSFALL, D., Works Manager,
Canada Wire & Cable Co., Ltd.,
Toronto, Canada.

HORSFALL, HERBERT, Pres. & Mgr. Dir.,
Canada Wire & Cable Co., Ltd.,
Toronto, Ont., Canada.

HUBBARD, E. J., President,
Hubbard Spool Co.,
Chicago, Ill.

HUGHES, CHAS. E., Sales Engineer,
Firth-Sterling Steel Company,
Indianapolis, Ind.

HUGHES, WILFRED A., General Foreman,
Gilbert & Bennett Mfg. Company,
Georgetown, Conn.

HUME, W. G., Manager
Wire Products Sales,
Pittsburgh Steel Co.,
Pittsburgh, Pa.

HUSSEY, R. M., Supt. Wire Dept.,
Jones & Laughlin Steel Corp.,
Aliquippa, Pa.

HYNDMAN, H. M., Superintendent,
Dominion Steel & Coal Corp., Ltd.,
Sydney, N. S., Canada.

IGOE, PETER, Treasurer
Igoe Brothers,
Brooklyn, N. Y.

INGHAM, T. S., Asst. Sales Manager,
American Chemical Paint Co.,
Ambler, Pa.

IREDELL, C. U., Supt. Div. 3B,
Westinghouse Elec. & Mfg. Co.,
Bloomfield, N. J.

IRELAND, D. B., Secy.-Treasurer,
Wolverine Bolt Co.,
Detroit, Mich.

IVES, C. G., Plant Superintendent,
The Acme Wire Company,
New Haven, Conn.

JACKSON, C. B. S., Manager,
H. L. Brown Fence & Mfg. Co.,
Cincinnati, O.

JAGIELSKI, OTTO F., Consulting Engineer,
Thompson-Judd Wire Machy. Co.,
Lynn, Massachusetts.

JEFFRIES, JAMES, Asst. Manager,
Driscoll Wire Company,
Shelton, Conn.

JENKS, FRANK, Production Supt.,
Rylands Brothers (Australia) Ltd.,
Newcastle, N. S. W., Australia.

JOHNSON, C. E., Supt., Rod & Wire Mills,
Bethlehem Steel Co.,
Sparrows Point, Md.

JOHNSON, F., General Manager,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.

KAVANAUGH, J. F., Manager, Wire Div.,
The C. O. Jelliff Mfg. Corp.,
Southport, Conn.

KENT, M. A., Manufacturing Director,
General Cable Corp.,
New York, N. Y.

KENYON, HAROLD G., Div. Supt.,
General Electric Co.,
Pittsfield, Mass.

KEYSER, HARRY, Wire Mill Foreman,
Kay Manufacturing Co.,
Brooklyn, N. Y.

KING, CARL, Superintendent,
Wickwire Spencer Steel Co.,
Palmer, Mass.
KINN, L. E., President,
Seneca Wire & Mfg. Co.,
Fostoria, Ohio.
KITSELMAN, HARRY L., Secretary,
Indiana Steel & Wire Co.,
Muncie, Indiana.
KNOLL, W. F., Superintendent,
Jas. Pender & Co., Ltd.,
St. John, N. B., Canada.
KNOWLTON, NEIL, H., Sales Engineer,
Electric Furnace Co.,
Salem, Ohio.
KRAKAUER, A., Secretary,
Kay Manufacturing Co.,
Brooklyn, N. Y.
KRAUSE, E. F., President,
E. F. Krause & Co.,
Los Angeles, Calif.
KRISE, R. W., Vice Pres. & Gen. Mgr.,
Milton Mfg. Co.,
Milton, Pa.
KRUEGER, E. W., Sales Representative,
Keystone Steel & Wire Co.,
Chicago, Ill.
KUNZ, MAJOR R. N.,
Naval War College, Newport, R. I.
LAIDLAW, W. A., Secretary-Treasurer,
Hamilton Wire Products, Ltd.,
Hamilton, Ont., Canada.
LAUDER, A., Works Manager,
Phillips Electrical Works, Ltd.,
Brockville, Ontario, Canada.
LAWRENCE, J. B., Sales Representative,
The Ironsides Company,
Columbus, Ohio.
LEACH, ROBERT H., Manager,
Handy & Harman,
Bridgeport, Conn.
LEPAGE, L. J. C., Director,
Sambre-Escaut, S. A.,
Fontaine-L'Eveque, Belgium.
LEWIS, KENNETH B., Consulting
Wire Mill Engineer,
Worcester, Mass.
LEWIS, RICHARD C., Engineer,
Farrel-Birmingham Co., Inc.,
Ansonia, Conn.
LONGNECKER, HARRY F., Sales Rep.,
Firth-Sterling Steel Co.,
McKeesport, Pa.
LONGWELL, JAMES R., Chief Engineer,
Carboloy Company, Inc.
Detroit, Mich.
LUND, C. T., Pres. & Gen. Mgr.,
New England High Carbon Wire Co.,
Millbury, Mass.
LYTLE, B. H., Manager Feeder Div.,
Westinghouse Elec. & Mfg. Co.,
East Pittsburgh, Pa.
MacDOUGALL, J. KENNETH, Manager,
Rylands Brothers (Australia) Ltd.,
Newcastle, N. S. W., Australia.
MacDUFF, H. G.,
Worcester, Mass.
MACKAY, W. ROY, Asst. Superintendent,
Rod & Wire Mill, Bethlehem Steel Co.,
Sparrows Point, Md.
MACKIE, I. C., Engineer of Tests,
Dominion Steel & Coal Corp., Ltd.,
Sydney, N. S., Canada.
MACKLIN, P. M., Exec. Vice-Pres.,
Wickwire Spencer Steel Co.,
New York, N. Y.
MacPHERSON, R. P.,
Schenectady Varnish Co.,
Schenectady, New York.
MADISON, A. G., Secretary,
Madison Wire Co., Inc.,
Buffalo, N. Y.
MANN, JOSEPH G., Treasurer,
Consolidated Wire & Associated Corps.,
Chicago, Ill.
MANNING, WM. H., Manager,
Insulating Dept.,
John A. Manning Paper Co., Inc., Troy, N. Y.
MARCUS, SAMUEL S., President,
Spring Products Corp.,
Long Island City, N. Y.
MARTIN, F. L., Dist. Sales Manager,
Warner Company,
Pittsburgh, Pa.
MELCHER, A. G., General Supt.,
Hoskins Manufacturing Co.,
Detroit, Mich.
MELLOWES, A. W., Vice-Pres. & Gen. Mgr.,
National Lock Washer Co.,
Milwaukee, Wis.
MELVILLE, N. F., Manager,
Manufacturers Wire & Stainless Steel Wire Sales,
Pittsburgh Steel Co., Pittsburgh, Pa.
MILLER, RANDOLPH V., President,
R. H. Miller Co., Inc., Homer, N. Y.
MORDICA, JOHN W., Representative,
Firth-Sterling Steel Co.,
McKeesport, Pa.
MORGAN, PHILIP M., Treasurer,
Morgan Construction Co.,
Worcester, Mass.
MORITZ, JOHN A., Superintendent Wire Mills,
Keystone Steel & Wire Co.,
Peoria, Illinois.
MORRISON, J. R., President,
Morrison Engineering Co., Inc.,
Cleveland, Ohio.
MORROW, J. G., Metallurgical Engineer,
Steel Co. of Canada, Ltd.,
Hamilton, Ontario, Canada.
MOSLO, ERNEST P., Owner,
Moslo Machinery, Inc.,
Cleveland, Ohio.
MOSTON, JOHN CHARLES, Works Mgr.,
Connollys Blackley, Ltd.,
Blackley, Manchester, England.
MUCKLEY, D. S., Superintendent,
Wire Mill, Colorado Fuel & Iron Corp.,
Pueblo, Colorado.
McCARTHY, B. L., Chief Metallurgist,
Wickwire Spencer Steel Co.,
Buffalo, N. Y.
McCOY, FREDERICK A., Engineer of Tests,
Sheffield, Steel Corp.,
Kansas City, Missouri.
McGOWAN, C. L., Superintendent,
Rod & Wire Mill,
Atlantic Steel Co., Atlanta, Ga.
McGREEVY, J. G., Sales Manager,
Apco Mossberg Corp.,
Attleboro, Mass.
McKEAN, JOHN R., Assistant Mgr. & Supt.,
Kennecott Wire & Cable Co.,
Phillipsdale, R. I.
McLAUGHLIN, T. F., Vice-President,
Rustless Iron & Steel Corp.,
Baltimore, Md.
McSHEEHY, T. H., Sales Representative,
Wickwire Spencer Steel Co.,
Chicago, Ill.

(*Please turn to Page* 666)

# YOURS... FOR THE ASKING

"PICKLING STEEL WITH MODERN INHIBITORS" . . .
. . . a new 32-page book on all the phases of pickling and inhibiting. An up-to-the-minute, liberally illustrated discussion of procedures, apparatus, handling equipment and the use of modern inhibitors with full data on Houghton's Acitrol 100, the inhibitor with "lasting efficiency." A publication worthy of the best technical libraries. We will be glad to send you a copy.

## E. F. HOUGHTON & CO.

240 W. Somerset St.,
PHILADELPHIA

Gentlemen: Please send me, free, a copy of "PICKLING STEEL WITH MODERN INHIBITORS".

*Name* ..... *Title* .....
*Company* .....
*Address* .....
*City* ..... *State* .....


MAKE YOUR PLANS NOW TO COME TO THE WIRE ASSOCIATION MEETING

## Wire Association Membership List—1937

*(Continued From Page 665)*

NEHRING, PAUL A., President,
Nehring Electrical Works,
De Kalb, Illinois.

NELSON, G. W., Superintendent,
Wickwire Spencer Steel Co.,
Worcester, Mass.

NEUHAUS, RICHARD, President,
Nukem Products Corp.,
Buffalo, N. Y.

NEWALL, A. P., Managing Director,
A. P. Newall & Co., Ltd.,
Glasgow, N., Scotland.

NORTON, L. H., Director of Purchases,
The National Screw & Mfg. Co.,
Cleveland, Ohio.

NOTVEST, ROBERT,
Indianapolis, Ind.

NOWELL, H., Representative,
Sir James Farmer Norton & Co., Ltd.,
Montreal, Ontario, Canada.

OBERHAUSER, THOMAS W., Sales Manager,
Wire & Tubular Products.,
Laclede Steel Co., St. Louis, Mo.

OLSON, ROBERT V., President
Mossberg Pressed Steel Corp.,
Attleboro, Mass.

PARKIN, WM. M., President,
Wm. M. Parkin Company,
Pittsburgh, Pa.

PATTERSON, JOHN W., Metallurgist,
Youngstown Sheet & Tube Co.,
Youngstown, Ohio.

PAULEY, RALPH H., Secretary-Treasurer,
Pittsburgh Tool Steel & Wire Co.,
Monaca, Pa.

PEARSON, O. G., Wire Mill Superintendent,
Continental Steel Corp., Kokomo, Ind.

PERSSE, B. D. S., Manager,
Laidlaw Bale Tie Co., Ltd.,
Hamilton, Ontario, Canada.

PETERSON, J. P.,
East Orange, N. J.

PETERSON, R. O., Development Engineer,
Osborn Manufacturing Co.,
Cleveland, Ohio.

PIERSON, W. D., Secretary,
Waterbury Farrel Fdry. & Machine Co.,
Waterbury, Conn.

POTTER, EARL R., Superintendent,
Standard Wire Corp. of Calif.,
So. San Francisco, Calif.

PRICE, W. B., Ch. Chemist & Metallurgist,
Scovill Manufacturing Co.,
Waterbury, Conn.

PURTELL, WM. A., President,
The Holo Krome Screw Corp.,
Hartford, Conn.

QUINN, J. J., Managing Director,
Metal Products, Ltd., Marina Industrial
Estate, Cork, Ireland.

RAITHEL, ARTHUR C., Factory Manager,
Vascoloy Ramet Corp.,
North Chicago, Ill.

RANDALL, H. L., President,
Riverside Metal Co.,
Riverside, New Jersey.

REA, V. F., President,
Rea Magnet Wire Company,
Fort Wayne, Indiana.

REEDER, A. M., Metallurgical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

RENFER, E. A., Manager, Sycamore Mill,
Anaconda Wire & Cable Co.,
Sycamore, Illinois.

RENNELL, H. H., Secretary-Treasurer,
The C. O. Jelliff Mfg. Corp.,
Southport, Conn.

RICHARDS, WALTER A., Sales Manager,
Micro Products Corp.,
Chicago, Ill.

RIGBY, JOHN, Director,
John Rigby & Sons, Ltd.,
Manchester, England.

RIVIERE, JORGE A., Manager, Wire Works,
Riviere y Cia, Ronda San Pedro 58,
Barcelona, Spain.

ROBERTSON, H. J., Secy.-Treas.
Port Wentworth Corp.,
New York City.

ROLLE, CARL, Mechanical Engineer,
International Nickel Co., Inc.,
New York, N. Y.

ROTH, EUGENE, Manager,
Union Wire Die Corp.,
Worcester, Mass.

ROTH, RALPH B., Purchasing Agent,
Ludlow Saylor Wire Co.,
St. Louis, Mo.

ROWLAND, W. A., Works Manager,
The Steel Co. of Canada, Ltd.,
Toronto, Canada.

ROYLE, CHAS. J., Vice-President,
Hudson Wire Co.,
Ossining, N. Y.

RUSSELL, RAYMOND F., Gen. Mgr.,
Sleeper & Hartley, Inc.,
Worcester, Mass.

RUTHERFORD, F. H., Superintendent,
B. Greening Wire Co., Ltd.,
Hamilton, Ontario, Canada.

RYAN, L. A., Assistant to President,
Fiske Brothers Refining Co.,
Newark, N. J.

RYLANDS, G. K., Gen. Mgr.,
Rylands Brothers, Limited,
Warrington, England.

SANDELIN, ROBERT W., Metallurgist,
Atlantic Steel Co., Atlanta, Ga.

SAWTELL, H. D., Gen. Wks. Mgr.,
Richard Johnson & Nephew, Ltd.,
Manchester, England.

SCHUELER, JULIAN L., General Superintendent,
Continental Steel Corp.,
Kokomo, Indiana.

SCHULTZ, W. J., Chief Engr.,
Firth Sterling Steel Co.,
McKeesport, Pa.

SCHWAB, W. H., Vice President,
General Rivet Co.,
Cleveland, O.

SCHWARTZ, WM., Secy. & Asst. Treas.
Anton Smit & Co., Inc.,
New York, N. Y.

SEIFERT, CHAS. G., Secy. & Supt.,
La Consolidada, S. A.,
Bis, Mexico City.

SELBY, C. H., Managing Director,
British Ropes Canadian Factory, Ltd.
Granville Island, Vancouver, B. C., Canada.

SENDZIMIR, T., Director,
Metallurgical Products Co., Ltd.,
Guernsay, C. I.
Paris, 17e, France.

SEYMOUR, LeROY, D., Metallurgist,
Youngstown Sheet & Tube Co.,
Youngstown, Ohio.


# GLADER WIRE NAIL MACHINERY

The Glader Nail Machine of to-day is the result of forty years experience in the building of wire nail machines.

High production and low upkeep cost are facts proven in actual mill practice. All recent major nail machine installations have been Glader machines exclusively.

Machines are built in ten different sizes, covering a range of nails from No. 22 wire 1/4" long, to 3/8" diameter wire 12" long, including our Single-Blow roofing nail machine.

Write for our catalogue and make your own comparison of our guaranteed production figures with what your present equipment is producing.

FOR FURTHER INFORMATION ADDRESS—

# WM. GLADER MACHINE WORKS

210 N. RACINE AVENUE

CHICAGO, ILLINOIS.

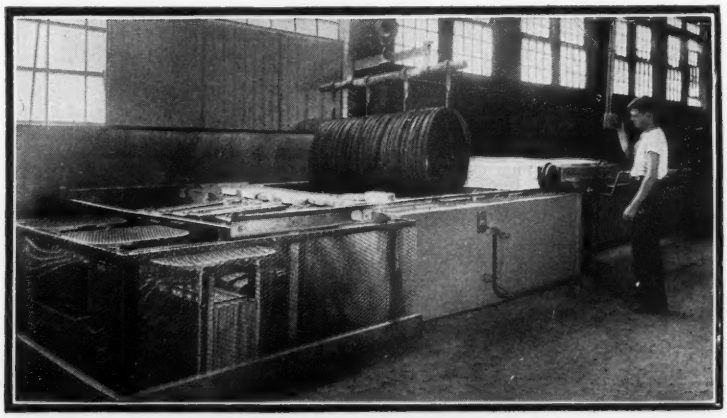
SHEARER, MAJOR A. M.,
Fort Monmouth, Oceanport, N. J.
SHERMAN, WALDO L., Secretary-Treasurer,
John Robertson Co., Inc.,
Brooklyn, N. Y.
SHILLING, J. H., Supt. Wire Div.,
Youngstown Sheet & Tube Co.,
Youngstown, Ohio.
SIMMONS, R. S., General Metallurgist,
Keystone Steel & Wire Co.,
Peoria, Illinois.
SIMONS, MORRIS, President,
Union Wire Die Corp.,
Stamford, Conn.
SIMPSON, C. M., JR., Captain,
Signal Corps., U. S. Army,
Army Base, Brooklyn, N. Y.
SKADE, EDWARD M., Foreman,
High-Carbon Wire Drawing Mill,
Nachman Spring-Filled Corp.,
Chicago, Ill.
SLIFKA, M., Purchasing Agent,
Parker-Kalon Corp.,
New York, N. Y.
SMITH, J. GODFREY, Vice-President,
Federal Wire & Cable Co., Ltd.,
Guelph, Ontario, Canada.
SMITH, VAN DORN C., Sales Dept.,
Oakite Products, Inc.,
New York City.
SMITH, W. W., Superintendent,
Pittsburgh Screw & Bolt Corp.,
Pittsburgh, Pa.
SOMERS, J. L., Vice-President,
Texas Nail & Wire Mfg., Co.,
Galveston, Texas.
SOMERVILLE, W. E., President,
W. E. Somerville Company,
Coal City, Illinois.
SOMMER, D. P., Vice-Pres. & Gen. Supt.,
Keystone Steel & Wire Co.,
Peoria, Ill.
SPEAR, EMERSON, Vice-President.
Pacific Wire Rope Co.,
Los Angeles, Calif.
SPOWERS, W. H., JR., Consulting Eng.,
New York, N. Y.
SPRUANCE, F. P., Sales Manager,
American Chemical Paint Co.,
Ambler, Pa.
STAPLES, HORACE A., V.-P. Chg. of Mfg.,
Phelps Dodge Copper Products Corp.,
New York City.
STEELE, R. J., Chief Engr.,
Firthaloy Division,
Firth-Sterling Steel Co.,
McKeesport, Pa.
STEVICK, R. S., Works Mgr.,
Firth-Sterling Steel Co.,
McKeesport, Pa.
STIRLING, A. B., Secretary,
N. Greening & Sons, Ltd.,
Britannia Works, Warrington, England.
STUMPF, GORDON A., Metallurgist,
Research Dept., Timken Roller Bearing Co.,
Canton, Ohio.
SULLIVAN, F. W., Treasurer,
Greif Brothers Cooperage Co.,
Cleveland, Ohio.
SUZUKI, MEISAKU,
Fukuoka-Ken, Japan.
SYMONDS, GEO. HENRY, Managing Dir.,
R. H. Symonds, Ltd., Valour Works,
Enfield, Middlesex, England.
TANG, S. Y., General Manager,
Canton Metal Window Mfg. Co.,
Honan, Canton, China.
TATNALL, RODMAN R., Engineer,
Wickwire Spencer Steel Co.,
Worcester, Mass.
THOLAND, NILS K. G.,
Ekstrand & Tholand,
New York, N. Y.
THOMAS, EARLE H., Superintendent,
Geo. W. Prentiss & Co.,
Holyoke, Mass.
THOMPSON, F. R., Commercial Manager,
Republic Steel Corp.,
Alabama City, Alabama.
TREUTING, HERBERT R., Supt. & Gen. Mgr.,
Savannah Wire Cloth Co.,
Port Wentworth, Ga.
ULLMAN, LEO, Managing Director,
Chiswell Wire Co., Ltd.,
London, N. W. 11, England.
VAN HOFFEN, H. A. M., Wire Works Mgr.,
Union Steel Corporation, Ltd.,
Vereeniging, Transvaal, South Africa.
VAN HOOK, CHAS. F., Manager, Cable &
Wire Machinery Div., & Chief Eng.,
Watson Machine Co., Paterson, N. J.
VAUGHAN, CURTIS H., Sales Engineer,
The Elcctric Furnace Co., Salem, Ohio.
VAUGHN, L. A., President,
Vaughn Machinery Co., Cuyahoga Falls, O.
VOIGTLANDER, CURTIS, Superintendent,
Wire Mills, Union Wire Rope Corp.,
Kansas City, Mo.
WARNER, CHAS. M., Supt. Wire Mill,
Scovill Manufacturing Co.,
Waterbury, Conn.
WEBB, E. H., President,
Webb Wire Works,
New Brunswick, N. J.
WEIKEL, G. A., Sales Engineer,
American Chemical Paint Co.,
Evanston, Ill.
WELLINGS, LT.-COMM. A. J.,
Inspector of Material, U. S. Navy,
Navy Gun Factory, Washington, D. C.
WELSH, J. ALAN, Sales Engr.,
Firth-Sterling Steel Co.,
McKeesport, Pa.
WESTPHAL, FREDERICK A., Supt.,
Wire Mills, Sheffield Steel Corp.,
Kansas City, Mo.
WHITNEY, LESLIE C., Chief Metallurgist,
Copperweld Steel Corp.,
Glassport, Pa.
WHYTE, R. B., General Superintendent,
Macwhyte Company, Kenosha, Wis.
WICKWIRE, CHESTER F., Vice-Pres.
Wickwire Brothers,
Cortland, N. Y.
WILCOX, RICHARD L., Vice-President,
Waterbury Farrel Foundry & Mach. Co.,
Waterbury, Conn.
WILEY, WILLIAM G., Asst. to General
Sales Mgr., General Cable Corp.,
New York, N. Y.
WILLIAMS, ROBERT C., Chief Chemist,
The Ironsides Company,
Columbus, Ohio.
WIND, WILLIAM J., Secretary,
Wilbur B. Driver Company,
Newark, N. J.
WINKLER, L. H., Metallurgical Eng.,
Bethlehem Steel Company,
Bethlehem, Pa.
WINTERSOHL, A. H., Supt.,
Firthaloy Division,
Firth-Sterling Steel Co.,
McKeesport, Pa.

*(Please turn to Page 668)*


# LAVITE ANNEALING

GIVES — more uniform product - - controlled atmosphere - - greater output - - lower cost - - better surface - - better shop conditions - - eliminates pickle - - eliminates burned out pots - - no excess heat; no dirt; no smoke.

RESULTS — of years of development of materials, processes and equipment as covered by our patents of many new and exclusive features.



LAVITE ANNEALING FURNACE—1000°—2000° F.

**THE BELLIS HEAT TREATING CO.**
Branford
Connecticut

a n d — LAVITE LIMITED,
Low Moor, Bradford
Yorks, England

## Wire Association Membership List—1937

*(Continued From Page 667)*

WITHINGTON, ROBERT W., President, American Insulating Machinery Co., Philadelphia, Pa.

WOOD, H. A., General Manager, E. H. Edwards Company, San Francisco, Calif.

WOODFORD, F. M., Western Mgr., Tungsten Electric Corp., Cleveland, O.

WOOD, MAURICE L., Chase Brass & Copper Co., Inc., Waterbury, Conn.

YORT, A. O., Superintendent, Wire & Tack Mill, Republic Steel Corp., South Chicago, Ill.

YOUNG, LAFE, General Superintendent, Laclede Steel Co., Alton, Ill.

ZAPP, A. R., Manager, Firthaloy Div., Firth-Sterling Steel Co., McKeesport, Pa.

Manufacturers of materials, tools and equipment for wire drawing and forming plants are constantly making improvements and additions to their lines. If you do not find the product or service in which you are interested, additional information will be supplied promptly. Simply address:

WIRE & WIRE PRODUCTS
17 East 42nd Street
New York City

## Author of Paper on Page 629 "Production of Copper from Mine to Mill"

WILLIAM H. BASSETT, JR.

Born December 25, 1896 at New Bedford, Mass. Attended Cheshire Academy, Cheshire, Conn. Graduated from M.I.T., 1918, Captain Ordnance Reserve, U.S.A. 1920-1929—American Brass Co.—Waterbury and Ansonia, Conn. 1929 to date—Anaconda Wire and Cable Co. From 1929-1936—Technical Supt. & Metallurgist. From 1937 to date—Manager, Metallurgical Development. Vice-Chairman of Committee B-1 of the A.S.T.M. On Executive Committee of A.I.M.E. Member of American Transit Association, A.I.E.E., American Society for Metals, The Wire Association. Licensed Professional Engineer in New York State.

Join the Wire Association

Annual Dues $10.00 — Includes:

1. The cooperative, confidential services of the Association through which members exchange ideas without identities being revealed and endeavor to help each other in plant management and process problems.
2. Participation in all Meetings of the Society.
3. A copy of the ANNUAL WIRE BUYERS' GUIDE AND YEAR BOOK OF THE WIRE ASSOCIATION.
4. A subscription for one year to the designated official publication of the society, WIRE AND WIRE PRODUCTS.

For detailed information address
Richard E. Brown, Secretary
17 East 42nd St. New York, N. Y.

STANDARD OR SPECIAL DESIGN MACHINES AND EQUIPMENT
FOR
WIRE, ROD OR STRIP MILL

Strip Coilers — Cold Rolling Equipment — Rod Coilers
Galvanizing and Tinning Equipment — Scrap Bundling Machines
Wire Drawing Machines - - Continuous and for Fine Wire

Cotter Pin, Edging, Straightening and Cutting Machines
Cleaning and Pickling Equipment — Pointers — Swagers — Wire Frames
Wire Puller Tongs

High Grade Equipment at Present Day Prices — Your Inquiries Invited

BRODEN CONSTRUCTION CO.
ENGINEERS - - BUILDERS
Wire Mill and Cold Rolling Equipment
11730 Harvard Avenue — CLEVELAND

# A Review of Recent Wire Patents

No. 2,088,040, METHOD OF AND APPARATUS FOR WIRE-DRAWING, Patented July 27, 1937 by Abraham Simons and Leon Simons, New York, N. Y.

The method includes the step which consists in pulling the wire continuously through a drawing die, while continuously subjecting the continuously moving wire to tension anterior to the die by passing the wire through a surrounding and abutting body of material which is maintained under pressure, and without substantially reducing the wire, the tension being at least fifty per cent of the elastic limit of the reduced wire, and not exceeding the elastic limit.

✦ ✦ ✦

No. 2,088,447, WOVEN WIRE BELT FOR PAPER MAKING MACHINES, Patented July 27, 1937 by Harry G. Specht, Montclair, N. J., assignor, by mesne assignments, to Encor Corporation, Belleville, N. J., a corporation of N. J.

In this belt, the warp knuckles cross the spaced crests of the weft wire and have their outer projecting surfaces substantially co-extensive transversely with the spaces between the crests.

✦ ✦ ✦

No. 2,088,448, WOVEN WIRE BELT FOR PAPER MAKING MACHINES, Patented July 27, 1937 by Harry G. Specht, Montclair, N. J., assignor by mesne assignments, to Encor Corporation, Belleville, N. J., a corporation of New Jersey.

**Complete Descriptions and Drawings of Patents May Be Had for 25 cents. Address, Wire & Wire Products, 17 East 42nd St., New York.**

In this belt, the warp knuckles cross the elongated faces of the weft wires and have their outer projecting surfaces about co-extensively with the elongated faces of the weft wires so as to produce substantially flat tapered stock supporting surface areas having flatness in both the length and breadth dimensions of the wire.

✦ ✦ ✦

No. 2,088,449, WOVEN WIRE BELT FOR PAPER MAKING MACHINES, Patented July 27, 1937 by Harry G. Specht, Montclair, N. J., assignor, by mesne assignments, to Encor Corporation, Belleville, N. J., a corporation of N. J.

According to this patent, the weft knuckles cross the elongated faces of the warp wires and have their outer projected surfaces substantially co-extensive transversely with the elongated faces, these outer projected surfaces being slightly flattened, by crushing of the weft wires at their point of engagement with the warp knuckles, so as to produce substantially flat paper stock supporting surface areas, the flatness being both in the length and breadth.

✦ ✦ ✦

No. 2,088,570, WIRE FEEDING MECHANISM, Patented August 3, 1937 by Benjamin B. Blanchard, Swampscott, Mass., assignor to United Shoe Machinery Corporation, Paterson, N. J., a corporation of N. J.

More specifically, this mechanism is provided for the purpose of forming and driving staples.

✦ ✦ ✦

No. 2,088,949, ELECTRIC CONDUCTOR, Patented August 3, 1937 by Alexander Fekete, Berlin, Germany, assignor to Radio Patents Corporation, New York, N. Y., a corporation of N. Y.

About the wire core is a layer of aluminum, with an insulating layer applied to the aluminum and comprising a chemical compound of aluminum. Other layers of aluminum and chemical compounds of aluminum may be applied to the conductor.

✦ ✦ ✦

No. 2,089,036, WIRE COILING MACHINE, Patented August 3, 1937 by Albert M. Olgay, Elmwood Park, Ill.,

*(Please turn to Page 670)*


"NEP"

**100% INHIBITOR**

**The Most Extensively Used Inhibitor in The United States, Canada, and Europe. The Application of "NEP" Effects a Saving of More Than the Cost of "NEP". Our List of Satisfied Customers Increases Each Year.**

✦ ✦ ✦

# —:— SUM-FOAM —:—

**Sum-Foam has been used by the Steel Industry successfully for 25 years. Sum-Foam is a mild inhibitor, but a powerful foam producer. There are several methods of pickling where it is necessary to have an etched finish on the metal for hot galvanizing and cold drawing . . . Sum-Foam gives positive control to the acid and steam vapors.**

**We Have Been Producing Good Inhibitors Successfully For 25 Years.**

# THE WM. M. PARKIN COMPANY

**Chemical Engineers to The Steel Industry**

**HIGHLAND BUILDING** **In Steel since 1860** **PITTSBURGH, PA.**

# A Review of Recent Wire Patents

assignor to The Lakeside Central Company, Chicago, Ill., a corporation of Ill.

This machine is adapted for forming helical wire springs. The patent comprises seventeen claims.

✦ ✦ ✦

No. 2,089,073, ELECTRICAL CABLE, Patented August 3, 1937 by Moyer M. Safford, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York.

Surrounding the wire conductor is an insulation which, on overheating, evolves non-combustible supporting gases.

✦ ✦ ✦

No. 2,089,301, WIRE ASSEMBLING DEVICE, Patented August 3, 1937 by Jacob Schwartzman, Brooklyn, N. Y., assignor to The Moore Company, Muncie, Ind., a corporation of Indiana.

This device is adapted for locating wire upholstering springs and includes a metal strip with a socket formed crosswise on the strip near its center and a loop formed on one end of the strip. A transverse socket is also formed near the free end of the loop, this socket interfitting and being adapted to receive a transverse retaining element for holding in place th wires clamped between the retaining element and the strip.

No. 2,089,335, METHOD OF SPOOLING BARBED WIRE, patented August 10, 1937 by George Lawson Brown, Preston, England.

More specifically, the method is adapted for spooling barbed wire so that the exposed convolutions present unbarbed surfaces, and consist in flat coiling the strands into a long helical coil with its barbs presented inwardly and then winding the long helical coil into a spool, the axis of which is at right angles to the axis of the long helical coil.

✦ ✦ ✦

No. 2,089,564, WIRE CUTTING MACHINE, Patented August 10, 1937 by Frank Magidson, Pittsburgh, Pa.

This machine is adapted for cutting wire into lengths, while the wire is in motion.

✦ ✦ ✦

No. 2,089,883, WIRE FINISHING, Patented August 10, 1937 by Frank H. Ellsworth, Worcester, Mass., assignor to The American Steel and Wire Company of New Jersey, a corporation of New Jersey.

In order to produce a shiny finish to wire, this inventor applies a lime coating to the wire and then contacts the wire with a wet lubricant associated with an organic substance such as will accelerate wetting of the coating. Thereupon, the wire is drawn through a reducing die while the coating is still wet.

✦ ✦ ✦

No. 2,090,510, ELECTRICAL CONDUCTOR AND METHOD OF MANUFACTURE, Patented August 17, 1937 by Harold F. Bower, Rome, N. Y., assignor to General Cable Corporation, New York, N. Y., a corporation of New Jersey.

About the stranded wire conductor is an insulating sheath with a concentric conductor over the insulating sheath, this latter conductor comprising a layer of circumferentially spaced conducting strands and a layer of semi-conducting material. Over all is a protective jacket. There are twenty-seven claims in this patent.

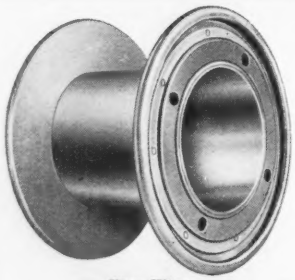
✦ ✦ ✦

No. 2,090,554, MECHANISM FOR MAKING TINSEL FABRIC, Patented August 17, 1937 by Harry Rubinstein, Brooklyn, N. Y.

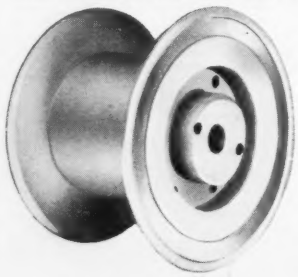
This mechanism is adapted for making tinsel out of flat metallic ribbon.

✦ ✦ ✦

Reissue No. 20,485, BOLT, Patented August 24, 1937 by John A. MacLean, Chicago, Ill., assignor to MacLean-Fogg Lock Nut Company, Chicago, Ill., a corporation of Illinois.

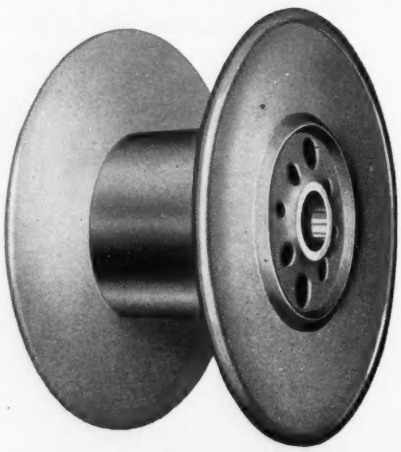
Fine Wire
High Speed Wire Drawing Spools



MOSSBERG **PRESSED STEEL** CORP.

IS keeping pace with requirements of the **Wire Industry's** demand for greater efficiency and offers a complete line of **Spools** and **Reels** for all shop manufacturing operations as well as for shipping purposes.

SPECIAL designs have been perfected for **High Speed Wire Drawing** and never before have tolerances been kept to such close limits in the production of **Spools** and **Reels** which is so essential to the user of **High Speed Machines** if maximum efficiency and uniformity of product is to be obtained.



Combination
500 lb. Capacity Wire Drawing—Annealing—Stranding—Reel

**MOSSBERG**
**Pressed Steel Corp.**
ATTLEBORO, MASSACHUSETTS, U. S. A.
Selson Machine Tool Co., Ltd., London England.

CONSULT OUR ENGINEERS ON YOUR SPOOL-REEL REQUIREMENTS

"CONVENTION HEADQUARTERS—THE HOTEL AMBASSADOR, ATLANTIC CITY, OCT. 18-23"

# A Review of Recent Wire Patents

The bolt has a threaded cylindrical body and a head on which is a downwardly extending flange, terminating in a cutting edge. The bolt is provided, adjacent its head, with a non-circular part projecting beyond the body and extending below this flange, the under surface of the head being tapered to provide an inclined face extending from the flange to the non-circular part and opposing the inner wall of the flange to the non-circular part and opposing the inner wall of the flange to compress the material to which the bolt is applied, forming a water-tight joint.

✦ ✦ ✦

No. 2,090,747, ARMORED ELECTRICAL CABLE, Patented August 24, 1937 by Harry Charmoy, Long Island City, N. Y., assignor to Hillside Cable Co., Hillside, N. J., a corporation of N. J.

So that the metallic sheath will not cut into the conductor wires, this inventor provides an insulating strip which is wound about the wires and under the cut end of the sheath.

✦ ✦ ✦

No. 2,091,136, SPRING COILING MACHINE, Patented August 24, 1937 by William H. Blount, West Brookfield, Mass., assignor to Sleeper & Hartley, Inc., Worcester, Mass., a corporation of Mass.

This wire coiling machine includes a rotary arbor having a flat annular surface for receiving the wire in flat condition and also having a parallel surface spaced from the flat annular surface, a distance greater than the thickness of the wire. The wire is pressed on a distorting device at a point over the flat annular surface so as to distort it out of its flat condition.

✦ ✦ ✦

No. 2,091,213, WIRE FABRIC CONVEYOR, Patented August 24, 1937 by Clarence E. Pink, Cambridge, Md.

The conveyor is made partly of relatively closely woven wire sections and intervening connection wire spirals of which the convolutions are generally oval form.

✦ ✦ ✦

No. 2,091,214, MULTISTRAND SPIRAL FABRIC, Patented August 24, 1937 by Clarence E. Pink, Cambridge, Md.

In this fabric is provided connector sections of which each includes a number of spiral wire strands threaded one into the other and a cross rod inserted through the convolutions of the strands in contact with the inner peripheries. The rod is secured at its ends to the extremities of the strands.

✦ ✦ ✦

No. 2,091,229, MECHANISM FOR CRIMPING WIRE MESH FABRIC, Patented August 24, 1937 by Noah S. Harter, Waukegan, Ill., assignor to Cyclone Fence Company, Waukegan, Ill., a corporation of Ill.

Included in the construction are guide and crimping rollers provided with grooves for permitting passage of the edges of the wire fabric.

✦ ✦ ✦

No. 2,091,245, METHOD OF PRODUCING COILED FILAMENTS, Patented August 24, 1937 by Ralph B. Thomas, Salem, Mass., assignor to Hygrade Sylvania Corporation, Salem, Mass., a corporation of Massachusetts.

The method includes paying-off the filament wire and a fine wire mandrel from suitable pay-off reels, then revolving the reels about a common axis to twist only the two wires together while maintaining the twisted wires under feeding tension, setting the filament wire in its twisted state and finally dissolving out only the twisted mandrel wire.

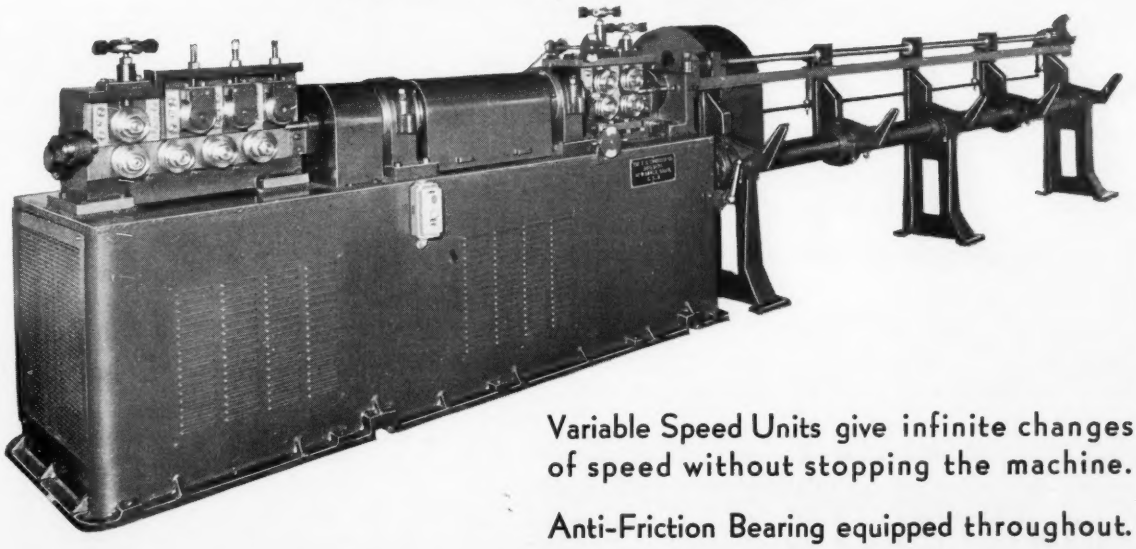
✦ ✦ ✦

No. 2,091,540, MEANS FOR MAKING REINFORCEMENT WIRE

*(Please turn to Page 672)*


SHUSTER DUAL CONTROL AUTOMATIC WIRE STRAIGHTENING AND CUTTING MACHINE

Contains many new features.



Variable Speed Units give infinite changes of speed without stopping the machine.

Anti-Friction Bearing equipped throughout.

THE F. B. SHUSTER COMPANY New Haven, Conn.

*Straightener Specialists Since 1866*

## A Review of Recent Wire Patents

*(Continued From Page 671)*

CAGES, Patented August 31, 1937 by William A. Whiting, Southgate, Calif., assignor to American Concrete & Steel Pipe Company, a corporation of Delaware.

This apparatus includes wire straightening and feeding rollers with a device for driving some of the rollers and an adjustable arm member mounted adjacent the rollers. An adjustable head is mounted on the end of this arm with an upper and a lower roller mounted on each head, the heads being provided with a pivoting device with a wire bending roller mounted on the pivoting device.

## The British Joint Committee on Materials and Their Testing

THE first technical discussion under the auspices of the Joint Committee of the Institution of Mechanical Engineers will be held in the Large Hall of the College of Technology, Manchester, England, on Friday, October 29th.

✦ ✦ ✦

THE following papers on notched bar impact testing have been promised:

**Paper No. 1—"The Physical Meaning of Impact Tests", by Professor R. V. Southwell, M.A., F. R. S., University of Oxford.**

**Paper No. 2—"Some Aspects of the Notched Bar Test" (in two sections namely—a brief review of past experiments in this country and an experimental exemplification of several features of the test), by Mr. L. W. Schuster, M.A., British Engine Boiler and Electrical Insurance Company, Manchester.**

**Paper No. 3—"The Development and Present Position of Continental Research on the Notched Bar Impact Test", by Dr. Ing. Max Moser, Messrs. Fried Krupp, Essen.**

✦ ✦ ✦

## Westinghouse Creates New Products Division

THE responsibility for the development of lines of activity which either are new in the art or which have not been previously undertaken by the company has been centralized by the Westinghouse Electric and Manufacturing Company with the formation of a New Products Division. Functioning the same as the other operating units of the company, this division will include separate engineering, manufacturing and sales departments.

✦ ✦ ✦

IN its new capacity the division will concentrate its facilities for the development and broadening the field of applications of products which have not reached the state of commercial apparatus. Then, after the field for each new product has been determined and the product has passed through the pilot plant stage, it will be absorbed by one of the regular company divisions. It will also be the responsibility of the new division to train a staff that will be adequate for the further promotion of the product.

✦ ✦ ✦

MR. H. M. Wilcox is manager of the New Products Division with Mr. H. W. Tenney as engineering manager and Mr. George F. Begoon as sales manager. Mr. Wilcox was formerly vice president of Electrical Research Products, Inc., a subsidiary of the Western Electric Company which was engaged in the development and exploitation of the patents of the American Telephone and Telegraph Corporation outside of the telephone field.

SCHUMAG

CONTINUOUS
ROD MAKING MACHINES

**Produce directly from the hot rolled or extruded coil material in a single, evenly continuous operation and with one operator, perfectly straight and highly polished ferrous and non-ferrous rods or bars; round, square, hexagon and flat. Capacities 1/16-1 inch.**

SCHUMAG

STRAIGHTENING AND
POLISHING MACHINES

**Straighten and highly polish:**

Round Rods
Turned or Ground Shafting
Ground Drill Rods
etc.

**Write for particulars**

W. A. SCHUYLER
Fisk Building
NEW YORK, N. Y.

# 'Round the World With the Wire Industry

## German Notes

GERMANY'S foreign shipments of wires in the first half of 1937 show a satisfactory increase over 1936. The following figures give the 1937 amounts (The first number in the brackets gives the 1936 amounts and the other number the quantity which was shipped to the United States): Wire rods 32,604 (17,217; 101), manufacturers' wire, bright 40,073 (33,505; 91), round and other wire, galvanized, tinned, coppered, or otherwise treated 54,366 (40,144; 1,040), wire nails 17,195 (16,943; 5,017). (The United States was by far the largest buyer; the second being Dutch East Indies with 1,686 and the third British India with 1,584. However, the quantity was small compared with 1936 when 10,789 tons were imported from Germany. However, all other countries have greatly increased their purchases.) Wire rope and strand 9,658 (8,059; 882). (In this product American purchases were only surpassed by British India which absorbed 996 tons.) Barbed wire 22,878 (23,711; 5,598). (In this product American purchases were surpassed only by Brazil, 7,316 tons, but fell short of 1936 when 6,825 tons were purchased from Germany). Wire netting and wire mesh 8,742 (7,056; 377 tons). Small wire wares (springs, rings, brushes, etc.) 3,986 (3,447; 102 tons).

✦ ✦ ✦

## German Exports and Imports

THE outlook is good for a further improvement of the export trade. Imports have been very small, the total quantity imported of wire and wire products was 2,930 tons (2,946), wire rods and 1,921 (2,088) tons of all other wire and wire products together.

## German Price Situation

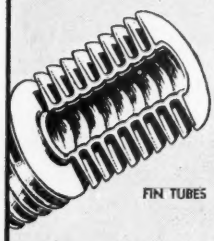
NO change of prices has occurred during the past weeks. The continental industry is maintaining prices for all markets. Although the July orders were comparatively small, the inquiries in August were heavy but have not yet resulted in much business since the shipment dates quoted by the European industry were too extended. Fourteen to eighteen weeks are still quoted for the average specification. Japanese competition has vanished since the outbreak of hostilities in the Far East.

✦ ✦ ✦

THE international wire rod cartel's extension was good only up to the end of August, but has been extended in the meantime for one month to the end of September. The difficulty is that no agreement can be reached on export sales of the recently expanded French-

(*Please turn to Page 674*)


OXYGEN-FREE **OFHC** REG. U. S. PAT. OFF. HIGH-CONDUCTIVITY


FIN TUBES

FINE WIRE

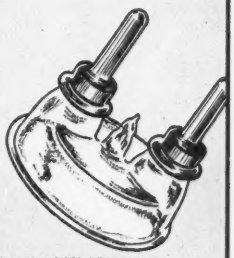
# COPPER

**IS SUPERIOR FOR ALL PURPOSES**

(*Produced by a Patented Process*)

•

***Ask either your own fabricator or us for the reasons***


BI-POSTS FOR LAMPS

BRAIDED CONDUCTORS

**UNITED STATES METALS REFINING COMPANY**

420 Lexington Avenue New York, N. Y.

TO CABLE & WIRE
MANUFACTURERS
ARE YOU INTERESTED?
IN THE STRENGTH AND TARE WEIGHT
OF YOUR
SHIPPING REELS.

THE STEVENS METAL PRODUCTS COMPANY
OF
NILES. OHIO
HAVE AN INTERESTING BROCHURE
ON THIS SUBJECT.

YOURS FOR THE ASKING.

MANUFACTURERS OF
STEVENS FLANGED STEEL CABLE REEL DRUMS
AND
ALL STEEL SHIPPING AND SHOP REELS
FOR THE WIRE AND CABLE INDUSTRY

## 'Round the World With the Wire Industry

(*Continued from Page 673*)

Belgian works. However there is not the slightest possibility that the cartel could collapse. The demand is firm and the price is well maintained at £ (gold) 7.0. Rods in heavy coils are still in active demand.

✦ ✦ ✦

GERMAN makers of wire mesh report that the Japanese competition—contrary to wire products—is very active. In this product, Japan did not imitate European manufacturers but has created a new type of mesh. The mesh is half-hard like the British (the continental industry sells chiefly the soft, the American the hard mesh), but it breaks easier than the British. The Japanese industry is lacquering the mesh like the European, not enamelling, it like the American. The lacquer is of excellent appearance in color and rather thin on the wire (which is a great advantage), but it springs off easily when the mesh is bent. Though good for use as mosquito mesh in large windows for which it is bought in Overseas markets, it is not practical for various manufactured articles.

✦ ✦ ✦

## International Ferrosilicium Syndicate

THE **International** Ferrosilicium Syndicate, which was to expire in June, was prolonged provisionally for one month. The members of the Syndicate met at the end of July to discuss price regulations in particular. Prices having increased considerably lately, several producers of this item (particularly Swedish) demanded an increase in sales prices, some members even going so far as to request complete liberty of action. No action has as yet been taken, it is stated.

✦ ✦ ✦

## Metallurgical Prospects in Eastern Russia

ACCORDING to unofficial information received, the keynote of the second Five Year Plan of the **Soviet Union** was a re-location of industry, both for the purpose of achieving more uniform distribution of production and of locating plants near to sources of power

and raw materials. The most conspicuous example is stated to have probably been the Ural-Kuznetsk Combine which is described as a large step toward the new territorial distribution of basic production units. The Plan is stated to have called for not only this particular development, but also for an increase in all eastern iron and steel production to one-third of the country's output of ferrous metals.

✦ ✦ ✦

### Rolling Mill Capacity in Soviet Russia

BY January 1, 1938, the capacity of the **Soviet Union** rolling mills will be approximately 20,400,000 metric tons (taking into consideration rolling mills which are expected to begin operations during the current year), according to unofficial information received. The total production capacity (including preparations, pipes from ingots and castings) will be about 26,000,000 tons, it is stated. This capacity would also include the "excesssive capacity of blooming mills (at a volume of 2,600,000 tons)"

✦ ✦ ✦

### Lithuanian Wire Industry Protected by High Tariff

INFORMATION received from the office of the American Consulate at Kaunas points out that the wire industry of **Lithuania** is protected by high import duties, so only special kinds of wire (not produced locally) are purchased abroad. Imports of iron and steel wire in 1936 amounted to 63.3 metric tons against 61.3 tons in the equivalent period of the preceding year. The largest wire manufacturers in this country are organized in a syndicate and their annual output increased from 710.3 tons in 1935 to 849 tons in 1936.

✦ ✦ ✦

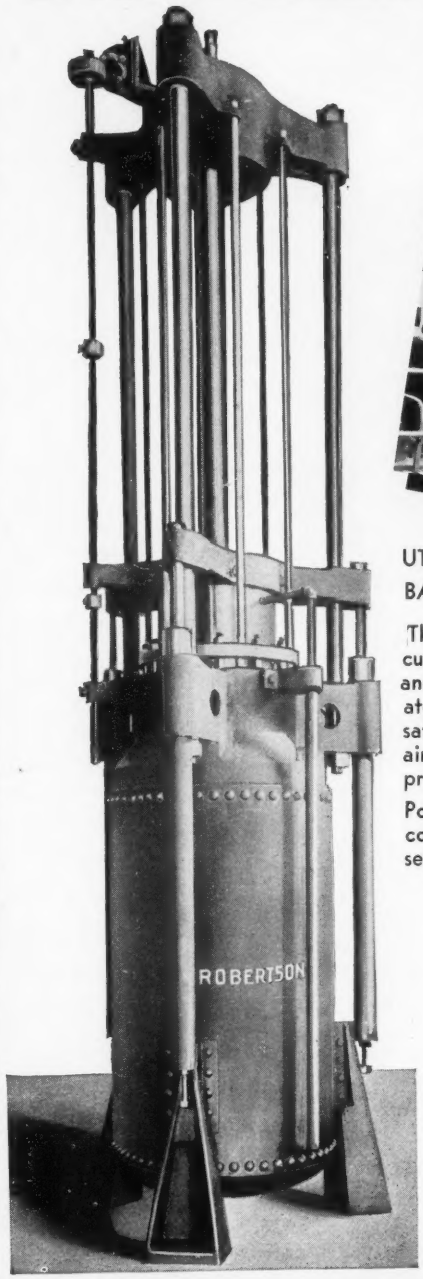
HORSESHOE nails are not manufactured in Lithuania, it is stated, although several attempts were made in the past to establish such an industry. The domestic consumption is estimated at 20 to 30 metric tons supplied principally by Sweden and Denmark.

(*Please turn to Page 676*)

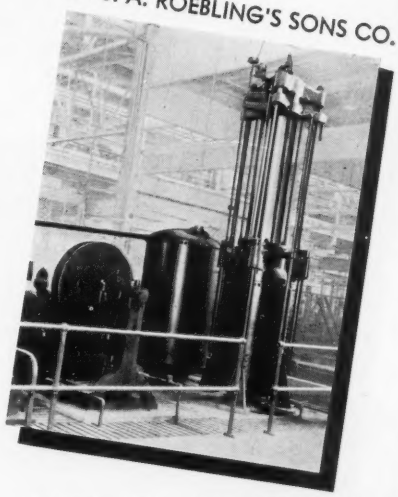

ROBERTSON

HYDRO-PNEUMATIC

ACCUMULATOR




AT J. A. ROEBLING'S SONS CO.



UTILIZES ITS AIR TANK AS A BASE: NO SPECIAL FOUNDATION

The Robertson Hydro-Pneumatic Accumulator can be installed anywhere - and save valuable floor space. It operates on only 175 lbs. air pressure - is safe - and is equipped with an auxiliary air compressor which maintains constant pressure in both cylinder and tank.

Positive and quick acting it gives low cost, highly efficient, trouble - free service.

Complete operating and performance data is yours to examine. A note on your business letterhead brings it to your desk — without obligation.

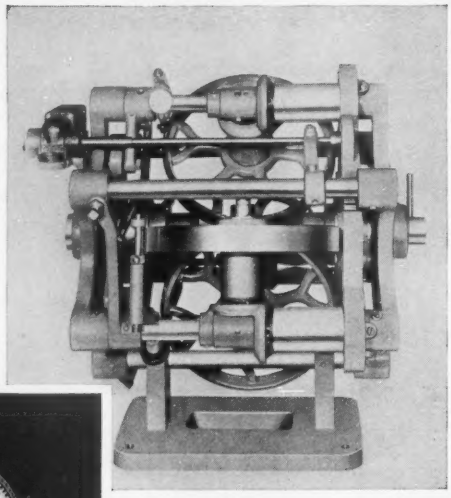
John ROBERTSON CO. INC. — Pioneers~Since 1858

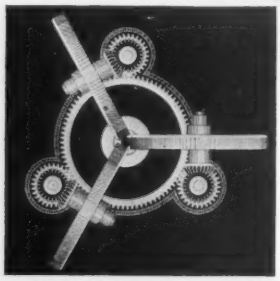
125-137 Water Street — Brooklyn, N. Y.

*If you want . . . . . .*

# ACCURATE MEASURE

. . . this is the measuring machine you *must* use. Shows *exact* linear measurement of bare, insulated, twisted pair, oval, odd-shaped, cable. Absolutely accurate at any speed! Speeds up production; saves loss and waste.





EXCLUSIVE "3-V" PRINCIPLE

A patented feature of Lyon Measuring Machine, gives absolute accuracy—permits high speed operation—eliminates vibration, slippage, error.

WRITE!

Inquiries and your fullest investigation invited.

**Lyon-Vail** *Special Machinery*

BROCKTON · MASSACHUSETTS · U. S. A.

## 'Round the World With the Wire Industry

(*Continued from Page 675*)

### Rapid Development in Japanese Hoop Industry

WITHIN the past two years, the hoop iron industry in **Japan** has developed very rapidly. There are two outstanding producers, one with capacity claimed to be 2,000 metric tons monthly of 19-44 mm. hoops and 6,000 tons of 50-95 mm. In addition, this plant purchased equipment from Germany for the production of broader sizes to the extent of 2,000 metric tons per month. Imports of hoop iron have come principally from England and Germany. The import trade has held up fairly well owing to the inability of domestic output to supply the wider sizes, but it is anticipated that imports will decline very materially in the near future.

✦ ✦ ✦

### Mexican Export Restrictions

ACCORDING to officials of the Mexican Customs Department and local dealers, there are (with two exceptions) no specific restrictions upon the export of finished and unfinished steel and steel products, pig iron, iron ore and scrap materials from Mexico. Waste bronze and brass from the munitions factories of the War and Navy Departments form one exception because written permission must be obtained for export of such items. Lathes capable of being used in military factories constitute the second exception, their exportation being prohibited. It is pointed out that the duties levied by the export tariff form the most important barrier to the export of iron, steel and scrap from Mexico, in fact, virtually prohibits them.

✦ ✦ ✦

### Dominion Steel & Coal To Take Over Control Of Graham Nail & Wire Corp.

ON September 1st Dominion Steel & Coal Corporation of

# Wire Run Out Stop

The wire runs between the fixed roller and the roller on the moving arm. When the wire runs out the rollers are forced together by a spring which also opens a switch which stops the motor driving the machine. The rollers are hardened and ground and are mounted on ball bearings so they can be run at high speed.

Price $15.00 Including Switch
F.O.B. Wallingford, Conn.

R. L. DAVIS ELECTRIC COMPANY, INC.
WALLINGFORD, CONN.

EUROPEAN AGENTS
SELSON MACHINE TOOL COMPANY, LTD.,
LONDON, ENGLAND

Montreal, Can., took over control of Graham Nail & Wire Corporation of Toronto, distributors of wire and flat steel products, furnishing an additional outlet for output of the corporation's Sydney mines. President Cross has indicated no new financing is required.

✦ ✦ ✦

CONSTRUCTION of a large addition to the plant of the W. S. Tyler Company at St. Catharines, Ontario, Canada, has been started. A building 100 by 200 feet will be erected for the manufacture of wire screens and other woven metal specialities. Newman Brothers have been given the general contract. Large expansion of the company's output is planned following completion of the addition.

✦ ✦ ✦

THE Steel & Tubes, Inc. patents covering its method for butt welding tubing and for removing the burr from the seam have been again upheld in a decision by Federal District Judge John P. Nields, for the District of Delaware.

✦ ✦ ✦

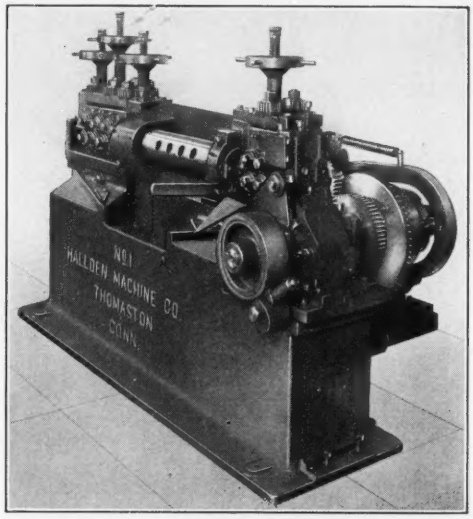
THE Court held that Clayton Mark & Co. of Chicago, Ill., which argued that the Johnston patent covering butt welding of tubing applied only to the use of alternating current, had infringed the patent assigned to Steel & Tubes, Inc., a subsidiary of Republic Steel Corp., granted August 23, 1921. Clayton Mark & Co. used direct current in its welding, which use the Court held, is entirely covered by the Johnston patent.

✦ ✦ ✦

IN holding that the Belmont patent covering apparatus for removing the burr by rolling the welded seam as the tube passes from the machine, had been infringed, the Court said that the patent applies to any apparatus which operates on the burr while it is hot and plastic. This patent was granted December 28, 1926.

MAKE YOUR PLANS NOW TO COME TO THE WIRE ASSOCIATION MEETING


AUTOMATIC WIRE STRAIGHTENER
with
FLYING SHEAR

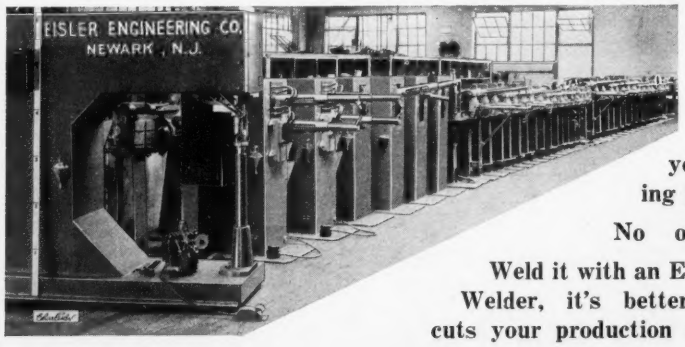



Guaranteed to produce a uniform diameter Rod, without markings.
Also high production, with accurate lengths.

THE HALLDEN MACHINE COMPANY
THOMASTON, CONNECTICUT

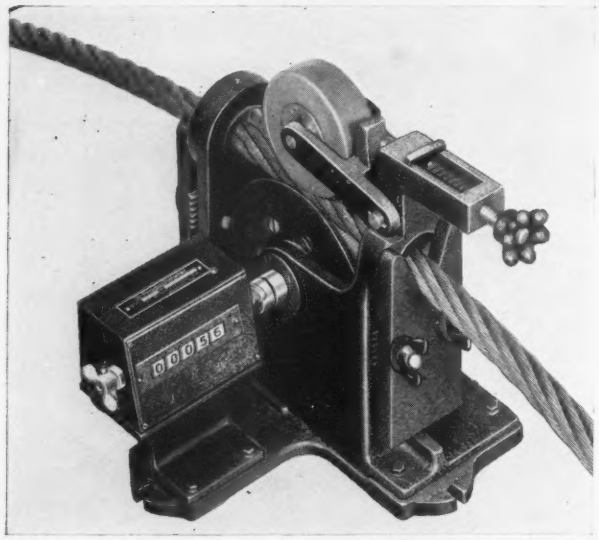
ELECTRIC SPOT and BUTT WELDERS
for UNIVERSAL USE
Sizes from ½ to 500 KVA

Visit our exhibit Booth No. G-71 Nat'l Metal Exposition,
Atlantic City, Write for our 100-page Catalog No. 38W




Send us your welding problems.
No obligation.
Weld it with an Eisler Spot Welder, it's better, faster, cuts your production cost.

EISLER ENGINEERING CO.
750 S. 13th St. (near Avon Ave.)
NEWARK NEW JERSEY



**A New Heavy Duty Wire Measuring Machine**

Productimer L-20 is a fast, accurate, rugged machine for lineal measuring of wire and cable $\frac{3}{16}$ to $1\frac{1}{2}$ in. dia. Maximum speed is over 5000 ft. a minute. Top reading counter is L-21, Compact in size and readily mounted anywhere. Ball bearing throughout. Instantaneous braking.

**DURANT MFG. CO.**
1928 N. Buffum St., Milwaukee, Wis.
180 Eddy Street, Providence, R. I.

Send for Bulletin 3 on Wire Measuring Machines, including smaller models for bare or insulated wire or cable .005 to .5 in. dia.



# APCO MOSSBERG CORPORATION

(FRANK MOSSBERG CORP.)

Lamb Street, ATTLEBORO, MASS.

Steel Spools for Annealing and Shipping
Steel Annealing and Stranding Reels
Steel Reels for Wire Rope
Steel Vulcanizing Reels
Steel Braiding Reels
Wire Weaving Bobbins

Manufacturers of a complete line of

**STEEL REELS - BOBBINS - SPOOLS**

for the Handling and Shipping of
COPPER and STEEL WIRE

Samples and Quotations upon Request


## Convention Notes

(*Continued from Page 662*)

izing, neutral hardening, reheating, annealing, drawing, and high-speed steel treating salts will be visually portrayed as to working ranges and uses.

✦ ✦ ✦

### General Electric Company

WITH the co-operation of the Jacobs Manufacturing Co., Hartford, Conn., General Electric will exhibit complete electric-furnace equipment for scale-free hardening and drawing of drill-chuck sleeves at the National Metals Exposition, Atlantic City, October 18-22, 1937. The equipment, which will be in actual operation, is a duplicate of that used by the Jacobs Manufacturing Co., and includes a scale-free hardening furnace, a drawing furnace, and degreasing equipment.

✦ ✦ ✦

IN addition to electric-furnace equipment, General Electric will demonstrate the latest types of arc-welding apparatus, including the new G-E Mutator (d-c) arc welder for use with light-guage metals; and new single-operator (d-c) sets, including both motor-generator combinations and gasoline-engine-driven equipments. A complete line of G-E arc-welding accessories will also be on display.

✦ ✦ ✦

MODERN industrial X-ray equipment will be shown by the G.E. X-Ray Corporation.

✦ ✦ ✦

### Leeds & Northrup Company

THE Leeds and Northrup Company's exhibit will be Booth F-62 consisting of an Instrument Section and a Furnace Section.

✦ ✦ ✦

### Instrument Section

ON display there will be the complete line of L & N Micromax temperature measuring equipment, consisting of portable instruments, manual indicators, round chart and strip chart recorders, and recording controllers. Two of these instruments, the cabinet-mounted temperature indicator and the Micromax indicating controller, are in re-designed cases shown for the first time at this Metal Show.

*Think of it!*

**95%**

**of the pickling rooms of the world**

**use**

**RODINE**

**in the pickling bath to save money and produce a better product.**

**If you have a metal finishing problem--pickling--cleaning -- painting -- consult our experts--Service Free.**

AMERICAN CHEMICAL PAINT CO.
AMBLER PENNA. Detroit
6339 Palmer Ave., E.

**WHOEVER UNDERSTANDS GERMAN**

Should Read

"Draht-Welt"
(Wire World)

A weekly for the wire industry and related lines.

Subscription price: Rm. 6.50 quarterly

Sample copies free on request from:

Martin Boerner — Verlag
Halle — Saale
Germany

## Furnace Section

**HOMO Tempering Furnaces** — The small tool-tempering Homo furnace and a large production Homo tempering furnace will be in operation. In the large furnace a temperature-exploration test will be run at frequent intervals to show the speed and uniformity of heating. A cut-away display will show the careful, sturdy construction of this furnace and the reasons why it requires so little maintenance.

✦ ✦ ✦

**TRIPLE-CONTROL Hump-Hardening Furnace** — This furnace will be in operation to demonstrate control of atmosphere, rate of heat input and quench point. Anyone bringing a suitable test piece to the booth may have it hardened.

**STEEL WIRE**

By MAURICE BONZEL

**Translated and Published by Kenneth B. Lewis Consulting Engineer**

**Price $15.00**

495 pages. 414 illustrations

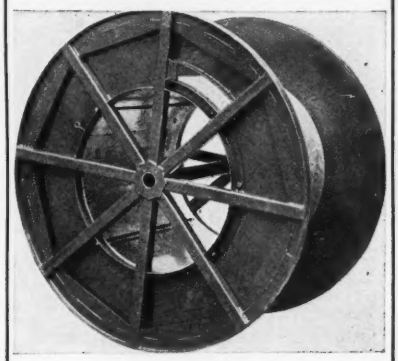
SEND ORDERS TO

**WIRE and WIRE PRODUCTS**

17 E. 42nd Street, New York

**ALL STEEL REELS**

**FOR SHIPPING**
**FOR STORING**
**CABLE AND WIRE**



**Last Longer**

**Constructed of corrosion resisting materials, three to four times the life of a wooden reel is a reasonable expectancy.**

**Give Greater Protection**

**Smooth inner surfaces, much greater strength with the absence of all cutting or abrading projections — these protect not only the cable but the men handling it.**

**Save On Freight**

**Appreciably lighter than wooden reels — cost less to ship — a cumulative saving that more than offsets increased first cost.**

**Reduce Investment**

**The longer life of R. B. Hayward Steel reels reduces the investment in reel equipment.**

*Write for description of construction and prices.*

**R. B. HAYWARD CO.**

**1714 Sheffield Ave.**

**Chicago, Illinois**

**Manufactured and sold under license arrangement with Electrical Research Products, Inc., Subsidiary of Western Electric Company, Incorporated.**

LEWIS HEAVY-DUTY WIRE MACHINES

No. 10-F "Travel-Cut", 5/8" Capacity

Lewis high speed, heavy duty, automatic wire straightening and cutting machines are built to meet the most accurate mill requirements on ferrous and non-ferrous wire.

See the **LEWIS "TRAVEL-CUT"** Automatic Wire Straightening and Cutting Machine in operation at the National Metal Exposition Atlantic City.

October 18-22. Booth B-4.

THE LEWIS MACHINE COMPANY

3440 E. 76 ST. — CLEVELAND, O.



# VIANNEY

*offers you*

1. **STANDARD WEIGHT DIAMOND DIES,** in all Diameters. Greatest Recutting Capacity.
2. **LIGHT WEIGHT DIAMOND DIES,** in most all Diameters, Selected stock, less Weight and lower Costs. Excellent Recutting Capacity.
3. **SPECIAL WEIGHT DIAMOND DIES,** for STEEL Wire. Long Bearings in Selected stones only.
4. **GUARANTEED WEIGHTS** cost no more than without the Weight Guarantee. Much Safer in the end.
5. **EXACTNESS & ROUNDNESS** available even in our .0004 (1/4 the size of a fine human hair).
6. **LARGEST STOCK** in U. S. A. in all Diameters insures Quick Deliveries and much more Selection.
7. **LOWEST PRICES,** commensurate with Quality combined with the largest manufacturing capacity.

**VIANNEY WIRE DIE WORKS • 250 EAST 43rd STREET • NEW YORK**


## William E. Acomb

WILLIAM E. ACOMB, for the past twenty-one years superintendent of the American Steel & Wire Company plants at Waukegan, Illinois, died suddenly at his home recently of a heart attack.

✦ ✦ ✦

HE was born in Detroit, Mich., on January 18, 1880, and was educated in that city's grammar and High schools. He graduated from the University of Minnesota with an engineering degree.

✦ ✦ ✦

MR. Acomb's connection with the American Steel & Wire Company began in March, 1905, when he was employed as Assistant to the Superintendent of the Allentown Works of the company. He remained in this capacity until January, 1906, when he was appointed Assistant Superintendent of the company's Rankin Works. In May, 1907, he was transferred to Donora as Assistant Superintendent of that division and in March he was made Superintendent of the Donora Works. He remained at that post until he was transferred to Waukegan as Superintendent in September, 1916, where he remained until his death on Saturday, August 28, 1937.

THERE WILL BE A REGISTRATION FEE OF $5.00

FOR THOSE ATTENDING THE WIRE ASSOCIATION TECHNICAL SESSIONS AND INFORMAL MEETINGS

ADMISSION WILL BE BY BADGE ONLY

To Those Registering and Attending the Meetings, stenographic copies of the discussions will be available without additional cost.

To all others $5.00 per copy.

MAKE YOUR PLANS NOW TO COME TO THE WIRE ASSOCIATION MEETING

## Statement of Ownership

Statement of ownership, management, circulation, etc., required by the Act of Congress of August 24, 1912 and March 3, 1933, of Wire & Wire Products published monthly at Washington, N. J., for October 1, 1937.

State of New York, County of New York, ss.: Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard E. Brown, who, having been duly sworn according to law, deposes and says that he is the President of Wire & Wire Products and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Quinn-Brown Publishing Corporation, 17 East 42nd St., N. Y. City; editor, Richard E. Brown, 17 East 42nd St., N. Y. City; managing editor, none; business manager, Richard E. Brown, 17 East 42nd St., N. Y. City.

2. That the owner is: (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.) Quinn-Brown Publishing Corporation, 17 East 42nd St., New York City, Jennie R. Baker, Hammonton, N. J., and Leta B. Brown, of 17 East 42nd St., New York City.

3. That the known bondholders, mortgagees, and other security holders owning or holding one per cent of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

RICHARD E. BROWN
(President)

Sworn to and subscribed before me this 28th day of September, 1937.

(SEAL) CHARLOTTE FRANKL,
Notary Public.


TO A FIRM REQUIRING A HIGH-GRADE WIRE MLLL SUPERINTENDENT

ONE of the most competent men in this industry will shortly be available for a new connection. Has had over twenty years' experience in the production of steel wire, both plain and galvanized, and the manufacture of common wire products. Thoroughly experienced in all phases of the industry.

+ + +

ANY firm interested in securing the services of such a man, address, in confidence, the Editor of WIRE AND WIRE PRODUCTS, 17 East 42nd Street, New York City.



# Your Membership Button!

This attractive blue and silver enamel button is now available to members. Symbolic of the profession and indicative of good standing in the Society, it is a badge to be proud of.

***Tear out this form, mail it in with $1.00 and get your button.***

Name .....

Address .....

THE WIRE ASSOCIATION
17 East 42nd St., New York, N. Y.

Premier
TRADE MARK REG. U.S PAT. OFF.
Diamond Dies

Long Life is assured when you use Premier Diamond Dies because the die channel of the diamond is of such design that when it has been polished to the next diameter a perfect die is obtained again.

*Ask about these dies at our Booth at Metal Congress to be held at Atlantic City, Oct. 18 to 22, 1937.*

DRIVER-HARRIS COMPANY
HARRISON - NEW JERSEY

## VERTICAL PLANETARY CABLING MACHINES

Two, Three and Four Conductors

Developed to Manufacture Cords Which Require a Smooth Outer Surface and Must Lay Without Kinking

MACHINE COMPLETE WITH FILLER AND BINDER ATTACHMENTS

COMPLETE INFORMATION FURNISHED ON REQUEST.

NEW ENGLAND BUTT COMPANY

DEPT. W-10, PROVIDENCE, R. I.

CHICAGO OFFICE, 20 NORTH WACKER DRIVE

## TRADE MARKS

Does your product bear a distinctive trade mark? If so, can you prevent competitors from using it? Have you registered it in the United States Patent Office? A patent on the product is not necessary in order to register its trade mark in the Patent Office. Write us for information on trade marks and the Federal registration that entitles you to display with your trade mark, the notice "Reg. U. S. Pat. Off."

**Lancaster, Allwine & Rommel**

Registered Patent and Trade Mark Attorneys

438 Bowen Bldg.—815 15th St. N. W. Washington, D. C.

## HOTEL DRAKE

South Carolina Avenue at Pacific

ATLANTIC CITY, NEW JERSEY

European Plan Hotel—Moderate Rates

150 Outside Rooms Beautifully Furnished

Also Small Apartments

Fully Equipped Including Electric Refrigeration

Convenient to Piers, Theatres and Churches

Also Bus and Railroad Depot

Garage Accommodations

For Literature and Rates, Address

W. Graham Ferry, Mgr.


### The Price Outlook For Tungsten Carbide

BECAUSE of the present world situation and the noticeable effect it has had on the price of tungsten, a recent announcement regarding the price outlook sent out by W. G. Robbins, President of Carboloy Company, Inc., Detroit, Michigan, is of particular interest at this time.

✦ ✦ ✦

IN his announcement, Mr. Robbins stated:

**"Because of the uncertainty in connection with the continuation of an adequate supply of tungsten of the proper purity from China, the General Electric Company, during the past few years, has purchased two tungsten mines in the United States. The material from both of these mines is of the high purity demanded for the most exacting requirements.**

**"At the moment, shipments of Chinese concentrates have been suspended and the price of tungsten has risen rapidly. However, the General Electric Company assures the Carboloy Company—its subsidiary—that an adequate supply of tungsten will be available from the operation of the domestic mines, to satisfy all Carboloy needs.**

**"Notwithstanding the increase in the market price of tungsten, we have every reason to believe that the price of cemented carbide manufactured by our Company will not be increased as a result of this condition."**

✦ ✦ ✦

USERS of cemented carbides should find this of unusual interest in view of the many anticipated and actual raises in prices of materials, such as tool steels, dies etc., having tungsten as an ingredient.

✦ ✦ ✦

FOUR new distributors for Republic's tubular products have been announced by N. J. Clarke, Vice President in Charge of Sales of Republic Steel Corporation, Cleveland, O. They are: The Bluefield Supply Co., Bluefield, W. Va.; Ormand Plumbing Supply Co., San Antonio, Texas; J. Gaber Co., Houston, Texas, and Morgan's Inc., Savannah, Ga. The complete range of tubular products, including Republic steel merchant pipe and Toncan Iron pipe, will be distributed by these well-known firms.

## New Coil Winding Company

ORLAND Murphy, president, announces the organization of Electrical Windings, Incorporated, 16 North May Street, Chicago, to specialize in the design and manufacture of all types of transformers, solenoids, chokes, magnets, etc. The new company is set up to design coils and mountings for any specific purpose, or to work from manufacturers specifications.

✦ ✦ ✦

MR. Murphy, president of the company, is a well known electrical engineer who has specialized for the past six years in designing and manufacturing special transformers, solenoids, coils, etc., for use in automatic coin machines, radio communications, testing equipment, public address systems, and other places where special windings are needed.

✦ ✦ ✦

MR. Murphy was formerly associated with Utah Radio Products and Standard Transformer Corporation, and has recently been chief engineer for Robertson-Davis.

✦ ✦ ✦

## Booklet on Cable Shipping Reels

THE Stevens Metal Products Company, manufacturers of steel cable reel drums and steel shipping and shop reels for the wire and cable industry, have just issued an interesting brochure entitled "The History of Fourteen Years Development in Cable Shipping Reels". Copy of brochure will be sent upon request. Address the Stevens Metal Products Company, Cable Reel Dept., Niles, Ohio.

Manufacturers of materials, tools and equipment for wire drawing and forming plants are constantly making improvements and additions to their lines. If you do not find the product or service in which you are interested, additional information will be supplied promptly. Simply address:

WIRE & WIRE PRODUCTS
17 East 42nd St. New York City

WIRE

BRIGHT • ANNEALED • COPPERED • TINNED and GALVANIZED—Coiled, Straightened and Cut to Length—in All Sizes.

| | | |
|---|---|---|
| ✓ MANUFACTURER | ✓ STAPLE | ✓ BUNDLING |
| ✓ FLORIST | ✓ TAG | ✓ BALE TIES |
| ✓ WEAVING | ✓ CLIP | ✓ BOOKBINDING |
| ✓ STONE | ✓ BALING | ✓ AND OTHERS |

WICKWIRE BROTHERS
CORTLAND · · · NEW YORK · · · U. S. A.

STEEL WIRE
By MAURICE BONZEL
A NEW BOOK ABOUT WIRE!
495 pages. 414 charts, photomicrographs and illustrations
Translated and Published by Kenneth B. Lewis, Consulting Engineer
Price $15.00
SEND ORDERS TO
WIRE and WIRE PRODUCTS
17 E. 42nd STREET, NEW YORK

Learn about PARALAN

Paralan will give your finished wire and wire products protection from atmospheric corrosion in the mill and in shipping. Paralan-coated wire can be spot welded or soldered without cleaning. Also, Paralan leaves surfaces in good condition for all types of finishes—enameling, japanning, lacquering, plating, etc.

Write for further information. We may be able to solve your difficulties.

AMERICAN LANOLIN CORP.
LAWRENCE, MASSACHUSETTS

Become Quality Conscious

For Larger Bundles, Higher Production and Lower Prices, Use

RUSCH DIAMOND DIES

RUSCH WIRE DIE CORPORATION
275 SEVENTH AVENUE, NEW YORK, NEW YORK
The All-American Made Diamond Die

FOR DRY AND WET DRAWING

**Wire Drawing Soaps**

Successfully meet recent special demands made by high-speed drawing and the added attention given to brightness and finish.

Send for special Wire Drawing Bulletin.

FOR FERROUS, NON-FERROUS WIRE

MAGNUS CHEMICAL COMPANY 188 South Avenue, Garwood, N. J.

## General Electric Makes Cost of Living Adjustment

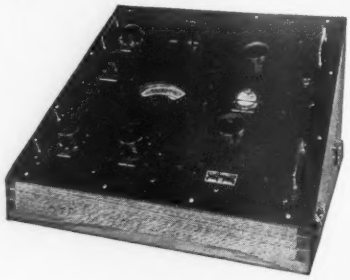
THE General Electric Company recently announced an increase of an additional one per cent in its Cost of Living Adjustment plan, raising it from four to five per cent. Instituted in October, 1936, the plan provides for automatic increases in employee earnings, based on the progress of the Cost of Living Index as published by the U. S. Department of Labor.

\+ + +

ACCORDING to the terms of the plan, if the cost of living goes up, one per cent is added to employees' earnings for each point of rise in the index up to 90. If the cost of living goes down, adjustments will be made until the index reaches 80. The plan further provides that the adjustment may take place at the half way mark between each point. The present index figure of 84.5 thus permits the employee earning increase to five per cent.

## Power Factor Measuring Equipment for Power Cables

THE quality of insulation of power cables is reliably indicated by measurements of power factor. High voltage tests may be made during production by means of the phase defect compensation method used in the equipment now offered by Leeds & Northrup Company. This equipment affords



an accurate means for making such tests, since it does not depend on the deflection of the wattmeter used. Inductance is introduced in the potential circuit of a sensitive dynamometer, so as to reduce its deflection to zero—thus avoiding the necessity for calibration of the instrument. An initial adjustment of the zero of the power factor scale, is made by applying suitable compensation, when using a high-voltage zero-loss air capacitor in place of the cable. The inductor then reads directly in per cent power factor.

\+ + +

THE complete equipment is described in Catalog E-54(3) which may be obtained from Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia, Pa.

Wire Drawing Diamond Dies

COCHAUD

WIRE DIE CORPORATION

300 W. 56th St., NEW YORK

Tel. Col. 5-1340

Wire Mill Equipment, Stranding, Insulating, Drawing, Welding

Thomson-Judd Wire Machinery Co.

Subsidiary of

Thomson-Gibb Electric Welding Co.

Lynn, Massachusetts.

The 1937 Wire Association Meeting Will be Held at Atlantic City, N. J. October 18th to 22nd, 1937

Kenneth B. Lewis

CONSULTING ENGINEER

Wire Mill Equipment, Layout and Practice

17 East 42nd St. New York City — 43 Midland St. Worcester, Mass.

Phone: Murray Hill 2-4188 — Phone 5-6033

J. W. ROCKEFELLER, JR.

Consulting Spring Engineer

Investigations—Layouts—Costs

Spring Coiling

72 Washington St., New York City

Telephone: Bowling Green 9-2739

WILLIAM GOULD, M. E.

CONSULTING INDUSTRIAL ENGINEER

INVESTIGATIONS — LAYOUTS — COSTS

WIRE DRAWING & SPRING COILING

80 Van Cortlandt Park So., New York City

ROYLE

PATERSON N J

BUILDING EXTRUDERS SINCE 1880

Pioneer builders of tubing and rubber covering machinery

JOHN ROYLE & SONS

PATERSON, N. J.

FOLDED PAPER FLATS

PAPER INSULATION YARNS

TWISTED "CELLOPHANE" YARNS

E. W. TWITCHELL, INC.

3rd & Somerset Sts. Phila., Pa.

EYELETS

ZINC WIRE

ZINC STRIP

THE PLATT BROS. & CO.

WATERBURY, CONN.

RUESCH

Machinery For

Wire, Tube, And Brass Mills

409 Mulberry St., Newark, N. J.

WIRE DRAWING MACHINERY AND EQUIPMENT

Rod Frames — 16" Frames, 8" Frames — Take-Up Frames, Wire Pointers—Puller Tongs.

General Castings for Wire Mill use.

Circulars on Request.

E. J. SCUDDER FOUNDRY & MACHINE CO.

TRENTON, N. J.

# Index to Advertisers


A

Ajax Manufacturing Co., The ..... 614
Ambassador Hotel ..... 663
American Brass Co., The ..... 533
American Chemical Paint Co. ..... 679
American Insulating Machinery Co. ..... 528
American Lanolin Co. ..... 683
American Pulley Co. ..... 570
Apco Mossberg Corp. ..... 678

B

Balloffet Dies & Nozzle Co., Inc. ..... 516
Bellis Heat Treating Co., The ..... 667
Bethlehem Steel Company ..... 523
Broden Construction Co. ..... 668

C

Carboloy Company, Inc. ..... 509
Cleveland Tramrail Division of Cleveland Crane and Engineering Co. ..... 548-549
Cochaud Wire Die Corp. ..... 684
Continental Steel Corp. ..... 612

D

Davis, R. L., Electric Co., Inc. ..... 676
Detroit Wire Die Co. ..... 518
Driver-Harris Co. ..... 681
Durant Manufacturing Co. ..... 678
Duriron Company, Inc., The ..... 639

E

Eisler Engineering Co. ..... 677
Electric Furnace Co., The ..... Back Cover
Elevator Supplies Co., Inc. ..... 564-565

F

Farrel-Birmingham Co., Inc. ..... 524
Firth Sterling Steel Co. ..... 534-587-605

G

General Electric Company ..... 517
Glader, Wm., Machine Works ..... 666
Gould, William ..... 684

H

Hallden Machine Co., The ..... 677
Hayward, R. B., Co. ..... 679
Houghton, E. F., & Co. ..... 665
Hubbard Spool Co. ..... 522
Hudson Wire Company ..... 512

J

Jones & Laughlin Steel Corp. ..... 525

K

Kelly Wire Die Corp. ..... 621
Keystone Steel & Wire Co. ..... 634

L

Laclede Steel Company ..... 599
Lancaster, Allwine & Rommel ..... 682
Leeds & Northrup Co. ..... 600
Lewis, K. B. ..... 684
Lewis Machine Co., The ..... 680
Lindberg Engineering Co. ..... 519
Lyon-Vail Machine Co., Inc. ..... 676

M

Magnus Chemical Co. ..... 684
Master Wire Die Corp. ..... 513
Micro Products Company ..... 520
Miller, R. H., Co. ..... 607
Morgan Construction Co. ..... Front Cover and 571
Morrison Engineering Co., Inc. ..... 511
Mossberg Pressed Steel Corp. ..... 670

N

National Machinery Co. ..... 608
National Metal Congress ..... 628-636
New England Butt Co. ..... 521 and 682
Nilson Machine Co., A. H., The ..... 664
Norton Company ..... 510
Nukem Products Corp. ..... 515

P

Parkin, Wm. M., Co. ..... 669
Platt Brothers & Co. ..... 684

R

Robertson, John, Co. Inc. ..... 675
Rockefeller, J. W., Jr. ..... 684
Royle, John & Sons ..... 684
Ruesch Machine Co., H. J. ..... 684
Rusch Wire Die Corp. ..... 683
Rustless Iron & Steel Corp. ..... 619

S

Schuyler, W. A. ..... 672
Scott, Henry L., Co. ..... 591
Scudder Foundry & Machine Co., E. J. ..... 684
Seymour Manufacturing Co., The ..... 531
Shuster, F. B., Co., The ..... 671
Sleeper & Hartley, Inc. ..... 576
Stevens Metal Products Co. ..... 674
Surface Combustion Corp. ..... 529
Syncro Machine Co. ..... 530

T

Thomson-Judd Wire Machinery Co. ..... 684
Torrington Manufacturing Co., The ..... 580-581
Twitchell, E. W., Inc. ..... 684

U

Union Wire Die Corp., The ..... 532
United States Metals Refining Co. ..... 673

V

Vanadium Alloys Steel Co. ..... 575
Vaughn Machinery Co. ..... Insert 556 A-B-C-D
Vianney Wire Die Works ..... 680

W

Warner Company ..... 514
Waterbury Farrel Foundry & Machine Co. ..... 526
Watson Machine Co. ..... Inside Back Cover
Wheeling Steel Corp. ..... 527
Wickwire Brothers ..... 683

Y

Youngstown Sheet & Tube Co., The ..... Inside Front Cover



Send For Your Free Copy Today!

"A Survey of the Wire and Wire Products Industry"!

Statistics — Market Research — Production Data

Wire & Wire Products

17 E. 42nd St., New York, N. Y.

# BUYERS' GUIDE

**For more complete information, consult the annual Directory, Index & Buyers' Guide.**

**ABRASIVES—**
Norton Co., Worcester, Mass.

**ANNEALING POTS AND BOXES—**
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.

**ANODES—Nickel**
Seymour Mfg. Co., Seymour, Conn.

**ANTI-RUST—**
Magnus Chemical Co., Garwood, N. J.

**ARMORING EQUIPMENT—**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Seymour Mfg. Co., Seymour, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

**BAKERS—Rod and Wire**
Lindberg Engineering Co., Chicago, Ill.
Morgan Construction Co., Worcester, Mass.
Morrison Engineering Co., Cleveland, O.

**BORON CARBIDE—**
Norton Co., Worcester, Mass.

**CARRIERS—High Speed Braider**
Apco Mossberg Corp., Attleboro, Mass.
Mossberg Pressed Steel Corp., Attleboro Mass.

**CEMENT FLOOR CLEANER—**
Magnus Chemical Co., Garwood, N. J.

**CEMENTS—Refractory**
Norton Co., Worcester, Mass.

**CHEMICALS—Cleaning**
American Chemical Paint Co., Ambler, Pa.
Houghton, E. F., & Co., Philadelphia, Pa.
Magnus Chemical Co., Garwood, N. J.
Parkin Co., The Wm., Pittsburgh, Pa.

**CLEANERS—Hand and Metal**
Magnus Chemical Co., Garwood, N. J.

**CLEANING & PICKLING EQUIPMENT—**
Broden Construction Co., Cleveland, O.
Duriron Co., The, Dayton, O.
Morgan Construction Co., Worcester, Mass.
Nukem Products Corp., Buffalo, N. Y.
Vaughn Machinery Co., Cuyahoga Falls, O.

**COATING—Protective**
American Lanolin Corp., Lawrence, Mass.
Houghton, E. F., & Co., Philadelphia, Pa.

**COILERS—Sheet, Strip and Wire**
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

**COLD HEADERS—**
Ajax Manufacturing Co., Cleveland, O.

**CONDUITS—Iron and Steel**
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**CONTROLS—Automatic**
Leeds & Northrup Co., Philadelphia, Pa.

**COPPER—**
U. S. Metals Refining Co., New York, N. Y.

**CRANES—Block Stripping**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**CRANES—Cleaning House**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**CRANES—Electrical Traveling**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**CRANES—Wire Mill**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

**DIAMOND TOOLS—**
Rusch Wire Die Corp., New York, N. Y.

**DIES—Diamond**
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Cochaud Wire Die Co., New York, N. Y.
Detroit Wire Die Co., Detroit, Mich.
Driver Harris Co., Harrison, N. J.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., The, Stamford, Conn.
Vianney Wire Die Works, New York, N. Y.

**DIES—Lead Extrusion**
John Robertson Co., Brooklyn, N. Y.

**DIES—Repairs & Re-Cutting**
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Cochaud Wire Die Corp., New York, N. Y.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., The, Stamford, Conn.
Vianney Wire Die Works, New York, N. Y.

**DIES—Rod and Tube Drawing**
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., The, Stamford, Conn.
Vanadium Alloys Steel Co., North Chicago, Ill.
Vianney Wire Die Works, New York, N. Y.

**DIES—Tantalum Carbide**
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., The, Stamford, Conn.
Vanadium Alloys Steel Co., North Chicago, Ill.
Vianney Wire Die Works, New York, N. Y

**DIES—Tungsten Carbide**
Balloffet Dies & Nozzle Co., Inc., Guttenberg, N. J.
Carboloy Co., Inc., Detroit, Mich.
Firth-Sterling Steel Co., McKeesport, Pa.
Kelly Wire Die Corp., New York, N. Y.
Master Wire Die Corp., New York, N. Y.
Rusch Wire Die Corp., New York, N. Y.
Union Wire Die Corp., The, Stamford, Conn.
Vanadium Alloys Steel Co., North Chicago, Ill.
Vianney Wire Die Works, New York, N. Y.

**DIES—Wire Drawing**
Detroit Wire Die Co., Detroit, Mich.

**DRAW BENCHES—**
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O.

**DRUMS—Flange Steel**
Stevens Metal Products Co., Niles, Ohio.

**DRUMS—Vulcanizing**
Mossberg Pressed Steel Corp., Attleboro, Mass.

**ENGINEERS—Consulting Wire Mill**
Gould, William, New York, N. Y.
Lewis, Kenneth B., New York, N. Y.

**ENGINEERS—Spring**
Gould, William, New York, N. Y.
Rockefeller, J. W., Jr., New York, N. Y.

**EQUIPMENT—Insulation Testing**
Leeds & Northrup Co., Philadelphia, Pa.

**EYELETS—Brass or Zinc**
Platt Bros. & Co., The, Waterbury, Conn.

**FILLERS—Paper for Cable**
E. W. Twitchell, Inc., Phila., Pa.

**FURNACE CONTROLS — Combustion**
Leeds & Northrup Co., Philadelphia, Pa.

**FURNACE CONTROLS—Draft**
Leeds & Northrup Co., Philadelphia, Pa.

**FURNACES—Annealing**
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

**FURNACES—Automatic**
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

**FURNACES—Bright Annealing**
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

**FURNACES—Electric**
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.

**FURNACES—Hardening and Tempering**
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Leeds & Northrup Co., Philadelphia, Pa.
Surface Combustion Co., Toledo, O.

**FURNACES—Lead Melting**
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Lindberg Engineering Co., Chicago, Ill.
John Robertson Co., Brooklyn, N. Y.
Surface Combustion Co., Toledo, O.

**FURNACES—Non-Oxidizing**
Bell's Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

**FURNACES—Normalizing**
Leeds & Northrup Co., Philadelphia, Pa.

**FURNACES—Wire, Strip & Sheet**
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
General Electric Co., Schenectady, N. Y.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

**GEARS—Wire Mill**
Farrel-Birmingham Co., Ansonia, Conn.

**GRINDERS—Roll**
Farrel-Birmingham Co., Ansonia, Conn.
Norton Co., Worcester, Mass.

**HANDLING EQUIPMENT — Material**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**HOISTS—Electric Traveling**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**HOISTS—Monorail**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**INHIBITORS**
American Chemical Paint Co., Ambler, Pa.
Houghton, E. F., & Co., Philadelphia, Pa.
Parkin, Co., The Wm., Pittsburgh, Pa.

**INSTRUMENTS—Electrical**
Leeds & Northrup Co., Philadelphia, Pa.

**INSULATION — Cable or Cable Filler**
E. W. Twitchell, Inc., Phila., Pa.

**LATHES—Die Reaming**
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

**LIME—Pulverized**
Warner Co., Bellefonte, Pa.

**LININGS—For Acid Tanks**
Nukem Products Corp., Buffalo, N. J.

**LUBRICANTS—For Metal Cutting, Stamping and Drawing**
Magnus Chemical Co., Garwood, N. J.

**LUBRICANTS—Wire Drawing**
Houghton, E. F., & Co., Philadelphia, Pa.
Magnus Chemical Co., Garwood, N. J.
R. H. Miller Co., Homer, N. Y.

**MACHINERY—Armoring (Cable, Wire Hose)**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
John Robertson Co., Brooklyn, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Braiding**
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Brazing**
Thomson-Judd Wire Machinery Co., Lynn, Mass.

# BUYERS' GUIDE, Continued

**MACHINERY—Bunching**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Bundling, Scrap**
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Cable, Electric**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Chain Making**
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.

**MACHINERY—Closing**
New England Butt Co., Providence, R. I.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Coil Winding**
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Coilers**
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Cold Heading**
National Machinery Co., Tiffin, Ohio.

**MACHINERY—Cold Heading With Wire Drawing Attachment**
Ajax Manufacturing Co., Cleveland, O.

**MACHINERY—Copper Wire Drawing and Rolling**
Elevator Supplies Co., Inc., Rahway, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

**MACHINERY—Covering Wire**
Syncro Machine Co., Newark, N. J.

**MACHINERY—Cutting**
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
F. B. Shuster Co., New Haven, Conn.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.

**MACHINERY—Enameling**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

**MACHINERY—Extruding**
John Robertson Co., Brooklyn, N. Y.
Royle, John & Sons, Paterson, N. J.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Flat Wire**
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Forming**
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Galvanizing Wire**
Broden Construction Co., Cleveland, O.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

**MACHINERY—Gang Winders**
H. J. Ruesch Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Grinding**
Norton Co., Worcester, Mass.

**MACHINERY—Insulating**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Syncro Machine Co., Newark, N. J.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Lead Encasing Presses, etc.**
John Robertson Co., Brooklyn, N. Y.

**MACHINERY—Lead Stripping**
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Lock Washer**
Sleeper & Hartley, Inc., Worcester, Mass.

**MACHINERY—Magnet Wire**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Material Handling**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**MACHINERY — Measuring Wire & Cable**
Davis, R. L., Electric Corp., Wallingford, Conn.
Durant Mfg. Co., Milwaukee, Wis., and Providence, R. I.
Lyon-Vail Machine Co., Inc., Brockton, Mass.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Nail and Tack**
Glader, Wm., Machine Works Co., Chicago, Ill.
Sleeper & Hartley, Inc., Worcester, Mass.

**MACHINERY—Panning**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

**MACHINERY—Pointing**
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

**MACHINERY—Rod Mill**
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.

**MACHINERY—Rolling Mill**
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

**MACHINERY—Rubber Strip Covering**
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Rubber Tubing and Straining**
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Royle, John, & Sons, Paterson, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Screw Wire**
Sleeper & Hartley, Inc., Worcester, Mass.

**MACHINERY—Special**
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY— Special — Combination Machine for Drawing, Cutting-to-length. Straightening and Reeling Bars from Coil in One Operation (Shumag Type)—**
W. A. Schuyler, New York, N. Y.

**MACHINERY—Spooling**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Sleeper & Hartley Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Spring Making**
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Staple**
Sleeper & Hartley, Inc., Worcester, Mass.

**MACHINERY—Straightening**
Broden Construction Co., Cleveland, O.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
Nilson, A. H., Machine Co., The, Bridgeport, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
F. B. Shuster, New Haven, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Stranding**
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Strip Steel**
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Swaging**
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

**MACHINERY—Taping**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Testing Size of Wire**
R. L. Davis Elec. Co., Wallingford, Conn.
Torrington Mfg. Co., Torrington, Conn.

**MACHINERY—Testing Wire**
Henry L. Scott Co., Providence, R. I.

**MACHINERY—Tinsel Rolling Mills**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

**MACHINERY—Trolley Wire**
Vaughn Machinery Co., Cuyahoga Fall, O.

**MACHINERY—Tube Mill**
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

**MACHINERY—Welding Wire**
Eisler Engineering Co., Inc., Newark, N. J.
Micro Products Co., Chicago, Ill.
F. B. Shuster Co., New Haven, Conn.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

**MACHINERY—Winding**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Wire Drawing**
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.

# BUYERS' GUIDE, Continued

Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

**MACHINERY—Wire Rope**
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

**MACHINERY—Wire Tinning**
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

**MACHINERY—Wrapping Wire**
W. A. Schuyler, New York, N. Y.

**MATERIAL HANDLING EQUIPMENT—**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**MILLS—Tandem Rolling and Edging**
Torrington Mfg. Co., Torrington, Conn.

**MONORAIL SYSTEMS—**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**NICKEL SILVER AND PHOSPHOR BRONZE—Rod, Wire and Strip**
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

**OVENS—Annealing or Drying**
Lindberg Engineering Co., Chicago, Ill.

**PAPER—Insulating**
E. W. Twitchell, Inc., Phila., Pa.

**PATENT ATTORNEYS—**
Lancaster, Allwine and Rommel, Washington, D. C.

**PICKLING COMPOUNDS—**
American Chemical Paint Co., Ambler, Pa.
Houghton, E. F., & Co., Philadelphia, Pa.
Parkin Co., The Wm., Pittsburgh, Pa.

**POTS — Annealing, Case Hardening and Tempering**
Lindberg Engineering Co., Chicago, Ill.

**POTS—Lead Melting**
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

**PRESSES—Hydraulic and Mechanical**
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

**PRESSES—Lead**
John Robertson Co., Brooklyn, N. Y.

**PULLERS—Wire**
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

**PUMPS—Hydraulic**
John Robertson Co., Brooklyn, N. Y.

**PYROMETERS—**
Leeds & Northrup Co., Philadelphia, Pa.

**RECORDERS—**
Leeds & Northrup Co., Philadelphia, Pa.

**REEL AND TENSION STAND—**
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

**REEL CRUTCHES—**
Watson Machine Co., Paterson, N. J.

**REELS—Annealing and Stranding**
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hayward, R. B., Co., Chicago, Ill.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

**REELS—Impregnating**
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hayward, R. B., Co., Chicago, Ill.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

**REELS—Steel**
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hayward, R. B., Co., Chicago, Ill.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

**REELS AND SPOOLS—Shipping and Shop**
Hayward, R. B., Co., Chicago, Ill.
Stevens Metal Products Co., Niles, Ohio.

**REFRACTORIES—High Temperature**
Norton Co., Worcester, Mass.

**ROD BAKERS—**
Morrison Engineering Co., Cleveland, O.

**RODS—Stainless Steel**
Rustless Iron & Steel Corp., Baltimore, Md.

**RODS—Wire—Non Ferrous**
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

**RODS—Wire—Steel**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**ROLLS—**
Farrel-Birmingham Co., Ansonia, Conn.

**RUST PROOF COMPOUND—**
American Lanolin Co., Lawrence, Mass.
Houghton, E. F., & Co., Philadelphia, Pa.

**SHEET—Steel**
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**SKIN PROTECTOR—**
Magnus Chemical Co., Garwood, N. J.

**SOAPS—Industrial and Wire Drawing**
Houghton, E. F., & Co., Philadelphia, Pa.
Magnus Chemical Co., Garwood, N. J.
R. H. Miller Co., Homer, N. Y.

**SPOOLS—Steel**
American Pulley Co., Philadelphia, Pa.
Apco Mossberg Co., Attleboro, Mass.
Hayward, R. B., Co., Chicago, Ill.
Hubbard Spool Co., Chicago, Ill.
Mossberg Pressed Steel Corp., Attleboro, Mass.

**STAINLESS STEEL—**
Rustless Iron & Steel Corp., Baltimore, Md.

**STRIP—Brass, Zinc and Non Ferrous**
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

**STRIP—Steel**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Firth-Sterling Steel Co., McKeesport, Pa.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling, W. Va.

**TANKS—Compound**
Watson Machine Co., Paterson, N. J.

**TESTERS—Wire**
Henry L. Scott Co., Providence, R. I.

**TRAMRAIL SYSTEMS—**
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

**TREADS—Safety**
Norton Co., Worcester, Mass.

**TRUCKS**
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Fall, O.

**TUBE BENDERS AND FORMERS—**
H. J. Ruesch Machine Co., Newark, N. J.

**VALVES AND FITTINGS—Acid Proof**
Duriron Co., The, Dayton, O.

**VULCANIZERS—**
Watson Machine Co., Paterson, N. J.

**VULCANIZING PANS—**
Amer. Insulating Mach'y Co., Phila., Pa.

**WELDERS—Spot and Butt**
Eisler Engineering Co., Inc., Newark, N. J.
Micro Products Co., Chicago, Ill.

**WIRE—Cold Heading**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**WIRE—Electric**
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

**WIRE—Enameled For Coils**
Winsted Div. of Hudson Wire Co., Winsted, Conn.

**WIRE—Manufacturers**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Wickwire Brothers, Cortland, N. Y.
Wheeling Steel Corp., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**WIRE—Nickel Silver and Phosphor Bronze**
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

**WIRE—Non Ferrous to Specification For Special Purposes**
American Brass Co., Waterbury, Conn.
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Winsted Div. of Hudson Wire Co., Winsted, Conn.

**WIRE—Spring**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Seymour Mfg. Co., Seymour, Conn.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**WIRE—Stainless Steel**
Rustless Iron & Steel Corp., Baltimore, Md.

**WIRE—Steel—Also Coppered Steel—Also Galvanized Steel**
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Jones & Laughlin Steel Corp., Pittsburgh, Pa.
Keystone Steel & Wire Co., Peoria, Ill.
Laclede Steel Co., St. Louis, Mo.
Pittsburgh Steel Co., Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling, W. Va.
Wickwire Brothers, Cortland, N. Y.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

**WIRE AND STRIP—Brass, Zinc**
Platt Bros. & Co., The, Waterbury, Conn.

**WIRE—Weaving—Non-ferrous**
American Brass Co., Waterbury, Conn.

This is a carefully classified index of concerns who specialize in this industry and who advertise regularly in WIRE & WIRE PRODUCTS. Please mention WIRE when writing to these firms.

# THE WATSON MACHINE COMPANY

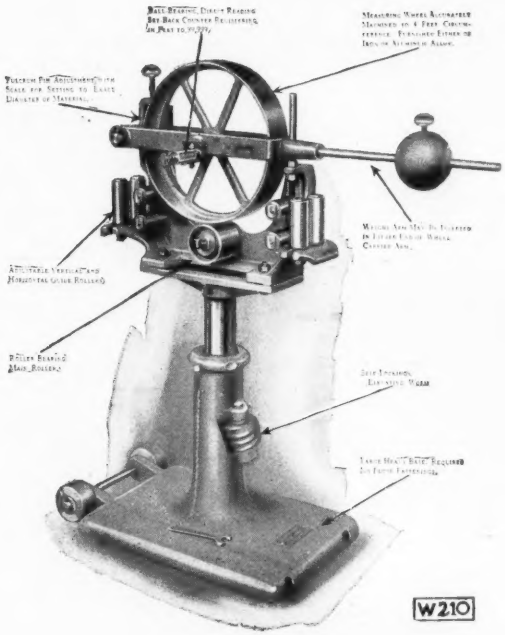
ESTABLISHED 1845

PATERSON, NEW JERSEY, U. S. A.

ENGINEERS - FOUNDERS - MACHINISTS

## WIRE MEASURING MACHINES

**Our Standard for years and still in demand**




Made in two sizes: DC-2 for diameters up to 1″, and DC-3 for larger diameters up to 3″.

Three types of Measuring Wheels: Hardened Steel for galvanized and hard surface wires; Semi-steel for bare wire; and Aluminum for covered wire.

Machines furnished without Floor Stands for table mounting.

Smaller Measuring Machines, suitable for wires below ½″ diameter, also manufactured—ALL SIZES CARRIED IN STOCK.

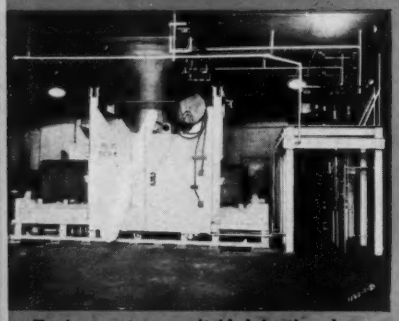
Send for bulletin for full details.

ELECTRICAL WIRE AND CABLE—WIRE ROPE AND CORDAGE MACHINERY

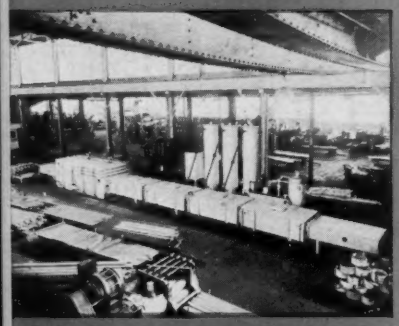
# LET US SHOW YOU

Bright Annealing Steel Tubing—continuously—5 to 25 foot lengths—2,000 pounds per hour.

Metal Radio Tube Parts are copper brazed and bright annealed continuously in furnaces of the above type.



Engine parts are nitrided in the above semi-continuous furnace—one of several similar installations.



Brass, Bronze and Copper in wire and strip are annealed continuously in this special atmosphere furnace.

## AT ATLANTIC CITY

WHILE you are attending the National Metal Exposition at Atlantic City - - October 18 - 22 - - permit us to show you some furnace installations we have made in that vicinity. Several of these are shown at left and below.

See also the large display of photographs and drawings of outstanding electric and fuel fired furnace installations in our Booth D-80 - (directly in front of stage). The latest developments in special atmosphere equipment for bright and clean annealing various ferrous and non-ferrous products including tubing, wire, strip, sheet, stampings and other finished and unfinished products are shown in this display.

These pictures also show some of our new continuous furnaces for copper brazing, bright hardening and heat treating with complete absence of scale as well as other continuous and batch furnaces of various types for normalizing, annealing, forging, billet heating and other heat treating processes.

See the large display of actual parts and products handled in these furnaces.

See the Elfurno generators for producing the inexpensive, protective atmosphere used in our controlled atmosphere furnaces.

See the new gas fired recuperative type radiant tube - the most uniform and the most economically operated radiant tube yet developed.

See the heavy cast metallic heating elements - the heaviest and most rugged element used in industrial furnace heating.

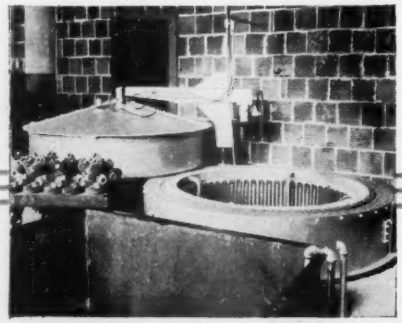
Our engineers will be glad to show you this equipment or work with you on any of your furnace or heat treating problems.

## THE ELECTRIC FURNACE COMPANY

SALEM, OHIO

Hotel Headquarters
During Exposition
THE AMBASSADOR HOTEL

Exposition Headquarters
Booth D-80 (directly
in front of stage)



Aircraft Motor Castings and other parts are heat treated in the above circular pit type electric furnace.

Gas Fired Radiant Tube Furnace equipped for special atmosphere for bright annealing copper tubing.

# THE ELECTRIC FURNACE CO

Fuel Fired
Furnaces

SALEM, OHIO

Electr
Furna